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PROJECT 3. WILD TROUT INVESTIGATIONS

Subproject 1. Wild Trout Regulation Effects on Angler Displacement
Subproject 2. Steelhead Exploitation Studies

PROJECT 6. BULL TROUT INVESTIGATIONS

Subproject 1. Rapid River Bull Trout Movement and Mortality Studies
Subproject 2. Bull Trout Aging Studies

by

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TABLE OF CONTENTS

Page

Project 3. Wild Trout Investigations
Subproject No. 1. Wild Trout Regulation Effects on Angler Displacement

LIST OF TABLES

LIST OF TABLES (Cont.)

LIST OF APPENDICES

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

TABLE OF CONTENTS (Cont.)

Subproject No.: 2. Bull Trout Aging Studies

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Page

ANNUAL PERFORMANCE REPORT

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Subproject No.: 1. Wild Trout Regulation Effects on Angler Displacement

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ABSTRACT

Idaho initiated a new regulation in its overall wild trout management program in 1992. The new regulation, which reduced the trout bag limit from the general 6 fish limit to a 2 fish limit, was termed the "wild trout" regulation. I conducted a statewide postal questionnaire to evaluate the immediate affect on angler use and possible displacement the first year following implementation of this regulation. The majority of survey respondents (57.7%) favored the wild trout regulations. Only 15.4% opposed them. However, support for extending the wild trout regulation in the future was lower with 42% in favor and 28.9% opposed.

Twenty-six percent of statewide survey respondents indicated they had fished at least one stream segment where wild trout regulations were implemented in 1992, but this is likely an overestimate. Most anglers (65.2%) who fished these waters indicated their fishing activity did not change as a result of the wild trout regulation. Of the anglers who changed their fishing activity on wild trout waters, 12.9% said they stopped fishing wild trout waters entirely and 16.7% fished less often on these streams following the regulation changes. This displacement of anglers was partially offset by 1.1% and 4.2% of the respondents who started fishing or started fishing wild trout waters more often, respectively. Displaced anglers were three times more likely to be harvest oriented than those who were not displaced. Most displaced anglers switched to fishing for trout in lakes and reservoirs (33%) or for trout in other streams and rivers with general regulations (6 fish limit) (29.5%). Only 10.7% switched to hatchery planted streams. Twenty-four percent of the displaced anglers stopped fishing as much, and 5.1 % stopped fishing altogether as a result of wild trout regulation implementation. Based on survey responses, out of a total sales of 420,938 licenses in 1992, an estimated 5,592 anglers (95% C.I. 3,558 to 14,618) fished less often and 1,687 anglers (95% C.I. 48 to 4,300) stopped fishing entirely as a result of the 2 fish bag limit.

Estimates of angler use of wild trout waters indicates a major overestimate compared to creel census estimates. Recall bias, survey complexity, and possible social desirability bias raise questions as to validity of results.

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INTRODUCTION

Idaho Department of Fish and Game (IDFG) began using restricted harvest regulations to enhance wild trout populations in 1971 in the St. Joe River and Kelly Creek (Rankel 1971, Ball 1971). Since then, the Department has expanded emphasis on wild trout management through the use of a variety of bag and size restrictions throughout the state. A recent statewide survey (Reid 1989) indicated the majority of Idaho anglers favored increased emphasis on wild trout management. Within the wild trout management section of the Fisheries Management Plan 1991-1995 (IDFG 1991) the Department describes a "wild trout" bag limit regulation. The "wild trout" designation included a 2 fish bag limit with no size or gear restrictions for selected waters throughout the state. No stocking of hatchery trout would occur in these waters. The Department recognized a reduction in bag limit alone would not result in major reductions in harvest because the majority of trout anglers do not harvest three or more fish (Thurow 1990, Hunt 1970). The management plan included emphasis on public education regarding wild trout values and encouraging anglers to voluntarily release wild trout. A companion program to the wild trout program included increased publicity on waters which do receive hatchery fish releases with a 6 fish bag limit. Ideally, those anglers who prefer to take home fish would shift from wild trout managed waters to hatchery trout managed waters (IDFG 1991).

Beginning in January 1992, the Department implemented the first wild trout (2 fish bag limit) regulations on Idaho streams (Appendix A). Additional streams were added in January 1994. The total number of miles of fishable streams currently managed under the wild trout regulations is approximately 3,250 miles. This represents 12.7% of the total 25,600 miles of fishable streams which support trout populations in Idaho (Bill Horton, IDFG, personal communication).

Following harvest restrictions, angler effort typically declines for an initial period (Shetter and Alexander 1962, Hunt 1970, Hunt et al. 1962, Jones et al. 1978, Alexander and Ryckman 1976, Latta 1973, Lindland 1977, Ball 1971, Rankel 1971, Lewynsky 1986). The Department recognized the potential to displace a portion of anglers fishing specific waters with implementation of the wild trout regulation. The Fisheries Management Plan 1991-95 recognized that for the wild trout regulations to be effective, effort by consumptive oriented anglers and harvest would have to be reduced (IDFG 1991). Sanyal and McLaughlin (1994) indicate that more complex and restrictive regulations can result in angler displacement. They indicate the occasional (inactive) anglers are more likely affected than those who fish frequently.

Angler displacement can occur in two forms. Anglers can select other types of fishing including other streams, lakes, and reservoirs with general limits versus streams with restricted bag limits, or warm water species versus trout. A second form of displacement of concern to IDFG is angler dropout from fishing entirely.

I initiated this study to evaluate angler displacement. I attempted to quantify the level of displacement and to identify changes in angler habits as a result of the wild trout regulation. I was interested in whether or not anglers changed fishing locations or decreased or stopped fishing activities.

OBJECTIVES

Research Goal: Determine changes in angler habits resulting from the wild trout regulations implemented in 1992.

1. To determine if implementation of the wild trout regulation results in measurable displacement of anglers.

2. Define the level of angler dropout due to wild trout regulation.

METHODS

For this study, use of the term "wild trout" refers specifically to the regulation of a 2 trout bag limit with no other size or gear restrictions. Readers should not confuse the context of "wild trout" regulations used in this paper with the larger statewide management direction for wild trout populations which may include restrictions on bag limits, size limits or gear allowed.

Questionnaire Design

The Department first initiated the wild trout regulations on streams in January 1992. I assumed displacement of anglers resulting from the wild trout regulations would likely occur in the first season after the change in regulation. I selected a random sample of 3,000 anglers from 1992 Idaho fishing license buyers data base to assess frequency of sampled anglers which use the wild trout waters. Using the 1990 and 1991 seasons as a baseline, anglers were asked to indicate any change in fishing habits due to the implementation of wild trout regulations in 1992. The sample included resident and nonresident license buyers.

I developed a survey to assess angler use and change of habits regarding Idaho streams managed with the wild trout regulation (Appendix A). The questionnaire included questions to assess attitudes towards fish harvest and the 2 fish bag limit, use of waters with 2 fish bag limit in 1992, and change in fishing habits relative to fishing wild trout waters. After developing the initial draft, IDFG personnel reviewed the survey for content and clarity. I then pre-tested the survey on ten local anglers. Input from staff and anglers was used to clarify or restructure survey questions to eliminate survey bias and clarify question content.

There were two mailings of the questionnaires. Each mailing consisting of three enclosures: 1) a survey, 2) a cover letter, and 3) a pre-paid return envelope. The questionnaire was initially mailed October 7, 1994, with a second mailing sent to non-respondents six weeks later on November 23, 1994. The cover letter explained the purpose and value of the study. The questionnaire was coded with a four-digit number to allow for follow-up mailing to non-respondents. These procedures follow recommendations of Dillman (1978).

I used a telephone survey to assess non-response bias. A random sample of 60 survey non-respondents were asked Questions 2, 3, 4, and 5 to determine if attitudes and fishing habits of anglers who responded to the questionnaire were representative of non-respondents.

Anglers were asked if they fished wild trout (2 fish bag limit) waters during 1992. If they said they were not sure, or indicated confusion over what waters were included, project personnel listed the 41 streams individually.

Questionnaire Analysis

I used SYSTAT software (SYSTAT Inc. 1991) program for data analysis. Questionnaire results were summarized as a percentage of sample respondents. The program calculated 95% confidence limits based on binomial distribution for each cell. Some questions offered "no opinion" as a question response. A "no opinion" response in the survey was treated as a response and differs from "no response". The number of respondents used to calculate a given percentage on each question is expressed as the N value for that question. During 1992, Idaho had 420,938 total fishing license sales (Altman 1993). I assumed the random sample was representative of all anglers and multiplied response percentages to individual questions by total license sales to estimate the total number of Idaho anglers affected.

I used a Chi-square test (Zar 1984) to test response differences between angler groups for individual questions. Power analysis of non-significant Chi-square results was calculated according to Cohen (1988).

I defined angler displacement as it relates to this study as those anglers who indicated in Question 6 that they either stopped fishing a wild trout water or stopped fishing that water as much. By design, I considered only respondents who indicated they fished designated wild trout waters (Question 5) in summarizing Question 6. Anglers who did not fish wild trout waters could not be displaced by this regulation.

A secondary objective of the study was to estimate angler use on the wild trout waters using survey responses and an expansion factor. The U.S. Postal Service returned 137 of the original 3,000 questionnaires mailed as undeliverable leaving an effective sample size of 2,863. A total of 1,041 (36.4%) useable questionnaires were returned. An expansion factor of 404 was computed (420,938 total license sales divided by 1,041 useable returned questionnaires). I multiplied the expansion factor by the sample response to estimate the total number of anglers fishing and angler days fished on each of the individual streams with wild trout regulations.

RESULTS

Angler profile

The 30 to 39 age class had the greatest number of respondents (27.3%) (Table 1). The 40 to 49 age class represented 24.3% of the sample and the 20 to 29 and 50 to 59 age classes had similar numbers with 16.2% and 15.2%, respectively. Male anglers made up 75.7% of the respondents. Residents made up 80.1% of the respondents compared to 19.9% for nonresidents.

Most anglers (53.4%) said they fished between 4 and 20 days per year with 19.7% indicating 31 days or more fished (Table 2).

Table 1. Demographics of 1992 wild trout questionnaire respondents by age, sex, and residence. Presented by number and percentage of sample.

Demographic character		Number	Percentage
Sex	Male	788	75.7
	Female	253	24.3
Age	14-19	55	5.3
	20-29	168	16.2
	30-39	283	27.3
	40-49	252	24.3
	50-59	158	15.2
	60 +	122	11.8
Residence	Idaho residents	834	80.1
	Non-residents	207	19.9

Forty-five percent of the respondents prefer to keep trout and try to get a limit compared to 31.1% who keep 1 or 2 fish and 23.9% who seldom keep any trout (Table 3).

The majority of respondents (57.7%) favored maintaining wild trout regulations on the existing rivers and streams. Only 15.4% opposed and 26.9% offered no opinion to the existing regulations (Table 4). The ratio of anglers who favor versus oppose the existing regulations equalled 3.7 : 1.

While more anglers (42%) support expansion of wild trout regulations to new waters compared to those opposed (28.9%), supporters do not comprise a majority and the margin of support is lower compared to that for maintaining existing waters (Table 4). Most of the lost support shifted to opposition (13.5% increase) to adding new waters. The ratio of those in favor versus opposed to future expansion of the regulation equalled 1.5 : 1.

More nonresidents favor maintaining existing or expanding future wild trout regulations compared to resident anglers (Table 4). The differences between resident and non-resident anglers was not significantly different regarding the existing regulations. The difference in support for expanding wild trout regulations was significant ($P<.01$).

Angler Use of Wild Trout Waters

Of the questionnaire respondents, 26.4% indicated they fished in at least one water with wild trout regulations during 1992 (Table 5). I expanded the sample responses to an estimate of total use for each stream managed under the existing wild trout regulations in 1992. The estimated use for each stream provides extremely high estimates of actual days fished for these streams (Table 6). The following are possible sources of error which could result in overestimates of estimated use: 1) Respondents may have confused exactly which stream segments were managed with the wild trout regulations. 2) Respondents may have confused wild trout sections with other stream sections managed under restricted harvest. 3) Recall bias over a period probably prevented accurate recollection of where and how many days anglers fished in 1992. 4) Social desirability bias could have influenced anglers to respond in a manner they believed represented IDFG management preference. 5) Attitudes of non-respondents may have differed from respondents, thereby invalidating our expansion estimate. More detail as to the likely bias for the estimates of use on wild trout streams will follow in the discussion.

Angler Displacement

The majority of anglers (63.8%) who fished wild trout waters in 1992 indicated they did not change their fishing habits due to the new 2 fish bag limits. Of the anglers who fished wild trout waters in either 1990 or 1991, 12.9% and 18.1% indicated they stopped fishing wild trout streams or stopped fishing as much in those waters, respectively (Table 7).

Table 2. The number of days fished per year by survey respondents.

	Days fished						
	0	1-3	4-10	11-20	21-30	31 or more	Total
Number	9	115	286	270	156	205	1,041
Percent	0.9	11.1	27.5	25.9	15.0	19.7	

Table 3. Angler fishing habits in rivers and streams.

	Fishing habits (keeping trout)		
Residence	Keep 6 fish	Keep 1 or 2	Seldom keep fish
Idaho residents	377	243	182
Non-residents	70	66	55
Total	447	309	237
Mean percent	45.0	31.1	23.9
95% C.I.	(41.2-48.8)	(27.6-34.7)	(20.7-27.2)

Table 4. Angler opinions of Idaho wild trout regulations. Responses by opinion of existing regulation and by potential of future expansion of regulations. Responses presented as percentage of sample.

	Angler opinion			
	Favor	Qopose	No opinion	
Maintain existing rivers and streams				
Residents	56.8	16.7	26.5	785
Non-residents	61.0	10.3	28.7	195
Total	57.7	15.4	26.9	980
95% C.I.	(53.8-61.4)	(12.7-18.3)	(23.6-30.4)	
Expand to new rivers and streams				
Residents	39.8	31.2	29.0	785
Non-residents	51.0	19.6	29.4	194
Total	42.0	28.9	29.1	979
95% C.I.	(38.2-45.8)	(25.5-32.5)	(25.6-32.7)	

N = Number of respondents.

Table 5. Percentage of surveyed anglers who reported. fishing wild trout (2-fish bag) waters in Idaho during 1992. Confidence interval of 95% listed for total sample.

	Fished wild trout waters (1992)	
	Yes	No
Percent	26.4	73.6
(95% C.I.)	(23.4-29.6)	(70.4-76.6)

Table 6. Estimated number of anglers who fished wild trout waters and the number of days they fished during 1992. Questionnaire response multiplied by 404 to estimate use by all licensed anglers.

Water	Number of anglers		Angler days	
	Sample	Estimate	Sample	Estimate
Movie River	16	6,470	61	24,666
Spokane River	32	12,939	229	92,598
Pend Oreille tributaries	27	10,918	148	59,845
Priest Lake tributaries	15	6,065	74	29,923
East Fork Potlatch River and tributaries	12	4,852	29	11,726
Dworshak Reservoir tributaries	41	16,579	155	62,676
North Fork Clearwater River tributaries	41	16,579	171	69,145
Lochsa River tributaries	19	7,653	70	28,305
Crooked Fork Creek	4	1,617	54	21,835
Selway River tributaries	22	8,896	57	23,048
Tenmile Creek	5	2,022	16	6,470
Johns Creek and tributaries	5	2,022	27	10,918
Granite Creek	14	5,661	65	26,283
Sheep Creek	19	7,653	72	29,114
White Bird Creek	10	4,044	17	6,874
Salmon River tributaries	66	26,688	275	111,199
Chamberlain Creek and tributaries	4	1,617	8	3235
Salmon River (upstream of Hell Roaring Creek)	104	42,053	466	188,431
Valley Creek	26	10,513	67	27,092
Camas Creek tributaries (MFSR)°	11	4,448	20	8,087
Indian Creek and tributaries (MFSR)	4	1,617	52	21,027
Loon Creek tributaries (MFSR)	10	4,044	19	7,683
Marble Creek and tributaries (MFSR)	12	4,852	55	22,240
Pistol Creek and tributaries (MFSR)	10	4,044	31	12,535
Sulfur Creek and tributaries (MFSR)	2	809	3	1,213
Rapid River and tributaries (MFSR)	13	5,257	28	11,322
Middle Fork Salmon River[b]	47	19,005	122	49,332
Squaw Creek and tributaries	29	11,726	167	67,528
South Fork Payette River	79	31,944	278	112,412
Bruneau River and tributaries	27	10,918	96	38,818
Jarbidge River and tributaries	15	6,065	50	20,218
Snake River (lower to upper Salmon Falls)	112	45,288	664	268,495
Malad River	35	14,153	153	61,867
Box Canyon Creek	19	7,683	73	29,518
Devils Corral Creek	10	4,044	28	11,322
Vinyard Creek	10	4,044	27	10,918
Little Wood River tributaries	42	16,983	156	63,080
Willow Creek (Camas Creek tributary)	25	10,109	89	35,988
Sublette Reservoir tributaries	11	4,448	39	15,770
Rapid Creek	19	7,683	70	28,305
Fall River and tributaries	59	23,857	254	102,707

[a] Middle Fork Salmon River tributary.

[b] Middle Fork Salmon River from Dagger Falls upstream to Bear Valley-Marsh Creek confluence.

wild trout waters in either 1990 or 1991, 12.9% and 18.1% indicated they stopped fishing wild trout streams or stopped fishing as much in those waters, respectively (Table 7). Therefore, 31 % of the anglers fishing wild trout waters were partially or totally displaced from these waters. This group is partially offset by anglers who indicated they started fishing or fished more often in wild trout waters (5.2% total). The displaced anglers potentially can move to fish other waters with standard bag limits or drop out of the sport of fishing.

Using Chi-square analysis, I tested anglers frequency of fishing (Question 2) against their reported displacement from wild trout waters (Question 6) and found no significant difference (.75 < P <.5) (Table 8). With small differences between observed and expected values and low sample size, the power of the test was only 27%. A highly significant relationship (P<.01) did exist between harvest attitude (Question 3) and reported displacement. Anglers who preferred to keep a limit of fish were more likely displaced than those who released most fish they catch (Table 8).

Most anglers who indicated they were displaced due to the wild trout regulation (Question 6) indicated they shifted fishing to other waters. The highest percentage of anglers (33%) switched to fishing for trout in lakes or reservoirs or moved to other trout streams with a 6 fish limit, both nearby (14.3%) or further away (15.2%) (Table 9). Twenty-four percent of the displaced anglers indicated they fished less often following the regulation changes and 5.1 % said they stopped fishing altogether.

I tested days fished and harvest attitudes against anglers' reported changes in fishing activity (Question 7). Anglers who fished less were more likely to decrease or quit fishing compared to those who fished more (Table 10), but the difference was not significant at *a* = .05 (.10 < P <.05, power = *65%).* No significant difference existed between harvest attitude and changes in fishing activity (.25 < P <.50, power = 17%) (Table 10).

Expanding the numbers of survey respondents who said they stopped fishing as much or stopped fishing altogether during 1992 as **a** result of the wild trout regulation yields estimates of 5,856 and 1,240 anglers, respectively, statewide who might have been so affected (Table 11). This represents 1.4% and 0.3% of the 420,938 license sales in 1992, respectively. These are likely overestimates if the number of anglers fishing wild trout waters (26%) is an overestimate as we suspect. These losses are only partially offset by a small percentage of anglers who responded they started fishing the wild trout waters or fished more often following 1992 regulation changes.

Non-response Bias

The telephone survey used to assess potential bias by survey non-respondents indicated only minor differences exist between questionnaire respondents and non-respondents (Table 12). No significant difference exists between the survey groups on their attitudes toward harvest versus release of fish. A similar percentage of questionnaire respondents and non-respondents indicated they fished the waters under wild trout management during 1992. No significant difference was detected between the percentage of non-respondents compared to respondents who favored maintaining existing or expanding future management of rivers and streams for wild trout management. No significant difference existed between the sex for non-respondents who were telephoned (78% males) versus respondents to the mail survey (76% males).

Table 7. Change in angling activity during 1992 for anglers who reported fishing wild trout (WT) water prior to 1992. Presented as percentage with 95% confidence limits.

Change in fishing activity	Percentage	95% C.I.	N
Stopped fishing WT waters	12.9	8.0 - 18.9	34
Stopped fishing WT waters as much	16.7	11.1 - 23.2	44
Started fishing WT waters	1.1	0.6 - 4.0	3
Started fishing WT waters more	4.2	1.5 - 8.3	11
No change in fishing habits	65.2	57.0 - 72.4	172
Total			264

N = number of respondents

Table 8. Change in angling activity on wild trout (WT) waters during 1992 for survey respondents who fished WT waters prior to 1992 (Question 6). Comparisons presented by days fished per year and fishing habits regarding fish harvest. Chi-squared analysis and power of test presented.

Angling activity change	Days fished oer season				
	1- 3	4-10	11 - 20	21 - 30	31 +
Displaced[a]	5	21	23	14	
Non-displaced[b]	11	33	56		

x^2 = 3.256, 0.75< P < 0.50 (power = 27%)

	Fishing habits		
	Keep a limit	Keep 1 or 2	Seldom keep any
Displaced[a]	55	14	7
Non-displaced[b]	50	75	58

x^2 = 45.70, P < 0.01

[a] Displaced anglers defined as those who stopped fishing WT waters as much or altogether.
[b] Non-displaced anglers include those who fished more often or did not change their fishing habits on WT waters.

Table 9. Change in where anglers fished during 1992 for anglers who fished wild trout (WT) waters prior to 1992. Results from 78 anglers who said they were displaced (fish less or stopped fishing) WT waters, Multiple responses given by some anglers.

Change in fishing locations	Anglers responding: Number	Anglers responding: Percentage"
Switched to nearby trout streams (within 10 miles) with general bag limit (6 fish)	16	20.5
Switched to other trout fishing further away (more than 10 miles)	17	21.8
Switched to hatchery planted waters (6 fish limit)	12	15.4
Switched to trout in lakes or reservoirs	37	47.4
Switched to warm water species	7	9.0
Do not fish as many days as before	19	24.4
Stopped fishing entirely	4	5.1
Total responses	112	

* Percentage of 78 anglers responding. Due to multiple responses, total exceeds%.

Table 10. Change in angling habits during 1992 for survey respondents who fished wild trout (WT) waters less than before (Question 7). Comparisons presented by days fished per year and fishing habits regarding fish harvest. Chi-squared analysis and power of test presented.

	Days fished per season				
Change in fishing locations	1-3	4-10	11 - 20	21 - 30	31 +
Fished less overall	2	3	1	0	0
Fished elsewhere	1	6	8	6	7

$x^2 = 8.607$, $0.10 < P < 0.05$ (power = 65%)

	Fishing habits		
	Keep a limit	Keep 1 or 2	Seldom keep any
Fished less overall	16	4	3
Fished elsewhere	38	10	3

$x^2 = 1.040$, $0.25 < P < 0.50$ (power = 17%)

Table 11. Estimated angler displacement of 1992 Idaho licenses anglers due to wild trout (WT) regulations. Displacement calculated as product of: 1) 420,938 licenses sold, 2) 26.4% of anglers who fished wild trout waters, and 3) 29.6% of anglers displaced from those waters times the percentages of anglers who stopped fishing or stopped fishing as many days. Results represent maximum estimates of displaced anglers due to potential positive response bias from anglers sampled.

Angler response as a result of WT regulations	Percentage of displaced anglers (95% CI.)	Estimated number of anglers affected
Stopped fishing as much	24.4(±9.6)	3,558 - 14,618
Stopped fishing altogether	5.1(±4.9)	48 - 4,300

Table 12. Comparison of angler responses between postal (n=1,041) and follow-up telephone (n=60) surveys for determination of non-response bias. Results provided as percentages.

	Postal survey	Telephone survey
Days fished per year		
0	0.9	14.3
1-3	11.0	14.3
4-10	27.5	17.1
11-20	25.9	20.0
21-30	15.0	2.9
31 or more	19.7	31.4
Fishing habits		
keep a limit	45.0	42.4
keep 1 or 2 fish	31.1	33.3
seldom keep fish	23.9	24.2
Opinion of wild trout regulation		
Maintain existing waters		
favor	57.7	67.6
oppose	15.4	8.8
no opinion	26.9	23.5
Expand to more waters in future		
favor	42.0	50.0
oppose	28.9	23.5
no opinion	29.1	26.5
Fished wild trout waters in 1992		
yes	26.4	27.3
no	73.6	72.7

There was a difference in days fished, with non-respondents indicating a higher percentage of anglers who do not fish at all and more who fish over 31 times per year. The difference was highly significant (P <.01).

A higher percentage of non-respondents favor the existing wild trout management compared to respondents of the general mail questionnaire. Though the difference was not statistically significant, management decisions based on questionnaire results should consider the estimate of public support as a minimum for existing and future wild trout regulations. Non-response information indicates public support for both existing and future expansion may be 5 to 10% higher. No comparisons of displacement are possible, as non-respondents were not surveyed on how their fishing habits were affected by implementation of wild trout regulations.

When asked why they had not responded to the questionnaire, most non-respondents indicated they did not fish the wild trout waters and did not think the questionnaire pertained to them. A second group indicated they were too busy or misplaced the questionnaire. A third group indicated they had returned the questionnaire. A final evaluation of responses did not show any questionnaires returned for the non-respondents who indicated they had sent them in, however.

DISCUSSION

The wild trout management program adopted in the 1991-1995 Management Plan (IDFG 1991) calls for a 2 fish bag limit with no other harvest restrictions (called the "wild trout" regulation) on some Idaho streams. For long-term success of this program, the Department recognized sport harvest in the wild trout waters would need to remain the same or decrease compared to pre-regulation levels. Reduction in bag limits by itself will not necessarily reduce angler harvest significantly because most anglers catch two or less fish per day (Thurow 1990, Hunt 1970). The Department combined the bag limit reduction with an education program promoting wild trout and encouraged anglers to recycle wild trout.

The Fishery Management Plan recognized the wild trout regulations would possibly reduce harvest by displacing harvest-oriented anglers who prefer to keep more than two trout. Bait anglers are not excluded from wild trout waters, but may choose other waters if harvest is an important part of their fishing values. Historically, restricted harvest regulations have initially resulted in decreased fishing effort (Shetter and Alexander 1962, Hunt 1970, Hunt et al. 1962, Jones et al. 1978, Alexander and Ryckman 1976, Latta 1973, Lindland 1977, Ball 1971, Rankel 1971, Lewynsky 1986).

Potentially, a program which results in the displacement of a portion of license buyers, for whatever reason, represents a quandary to a management agency concerned with maintaining a clientele. Nationwide fishing license sales have been flat or declining since the late 1980s (Duda 1993, Harrington Market Research 1992, Felder and Sweezy 1991, American Fisheries Society 1990). Sanyal and McLaughlin (1994) indicate more complex regulations and competing leisure time activities are partially responsible for loss of license buying anglers. Anglers who are more enthusiastic persist in the sport, compared with occasional anglers who are more likely to drop out (Duda 1993).

Although quantifiable estimates are difficult to obtain, the number of stream miles with harvest restrictions in Idaho is clearly at or near the top nationwide. Thus the potential for displacement or elimination of anglers is a concern in Idaho. The Department recognizes an important need to balance reduction of harvest of trout in wild trout management waters with providing acceptable alternatives for potentially displaced harvest-oriented anglers.

The intent of this survey was to determine, after-the-fact, the magnitude of angler displacement as a result of initiation of the wild trout management program in 1992. However, the expanded angler use data indicates major errors exist in the data reported by survey respondents.

Social researchers are constantly concerned about response bias in public surveys (Deutscher 1973, Sudman and Bradburn 1974, Wyner 1976). Factors which can result in response bias to survey results include asking users to recall events more than 12 months in the past (Westat, Inc. 1989; Harris and Bergersen 1985; Chase and Godbey 1983), perceived social desirability attached by the respondents to question answers (Sudman and Bradburn 1974, Chase and Godbey 1983, Chase and Harada 1984) and the potential for respondents to be confused by complex questions (Sudman and Bradburn 1974, Dillman 1978). Generally, these factors result in significant positive response bias in self-reported use surveys.

A number of these factors appear to have affected our survey results. The expansion of reported angler use by stream (Table 6) may be as much as 10-fold greater than actual recent creel census estimates for the similar sections on the same waters (Table 13). The time delay between 1992 and the time of the survey in 1994 undoubtedly contributed to difficulty in accurate recall and contributed to angler recall bias in reported fishing use.

Survey results suggest 26% of the anglers fished at least one of the wild trout waters during 1992. Statewide only 12.7% of the rivers and streams which support trout are managed under wild trout regulations, and many of these streams receive relatively lower fishing effort due to locations away from population centers. I believe anglers are not likely to fish these waters in a greater proportion than they are represented within the state. Surveyed anglers were asked to recognize wild trout streams by name and, in some cases, by location. Additionally, only portions of some streams are managed under the wild trout regulation. Overestimation of the percentage of anglers who fish wild trout waters may have resulted from surveyed anglers misidentifying waters managed under wild trout regulations. Additional confusion could occur by anglers who fished waters with a 2 fish bag limit in conjunction with additional harvest restrictions (e.g., South Fork Snake River). Waters which included additional restrictions on fish size or terminal gear were outside of the scope of this study.

Through use of 1992 license data base, I tried to evaluate those anglers who were affected during the first year of implementation of the program. In retrospect, given the complexity of the survey, the geographic distribution of the wild trout waters, and a recall period of 2 to 3 years after potential angler displacement due to the regulation, the mail survey design I selected likely could not produce reliable angler use data. The apparent errors in expanded angler use raise questions as to the validity of the 26% of the respondents who reported to have fished at least one of the wild trout management waters during 1992. In Idaho only 12.7% of the river and stream miles are managed under the wild trout 2 fish bag limit regulations, and these waters are often lightly fished. Therefore, I question the 26% reported use. However, this factor alone may not account for the large discrepancies derived from this survey. Recall bias and social desirability bias also likely inflated the reported number of days fished by survey respondents.

Table 13. Comparison of estimated angler use from creel census records versus expanded 1994 wild trout survey data. Estimated number of angler days derived by dividing anglers hours by 2 hours fished per angler day if data not otherwise provided.

			Estimated angler effort (days)	
Water body	Source	Year	Creel census	Wild trout survey
Spokane River	Davis (1992)	1990	3,100	92,600
Crooked Fork Creek[a]	Keating (1968)	1966	1,450	21,800
South Fork Payette[a]	Elle (1993)	1992	8,000	112,400
Snake River Lower Salmon Falls area	Partridge and Warren (1994)	1990	21,850	268,500

[a] Census sections do not correspond to wild trout regulation. Figures provide comparative information.

In retrospect, it is questionable if a mail survey could produce unbiased results in our situation. The recall period was far too long. Additionally, the number and geographic distribution of the streams involved in the 1992 initial regulation change was too broad and likely caused confusion in respondents ability to accurately identify their use of wild trout waters. Mail survey design provides little opportunity to evaluate social desirability response bias.

For future similar studies to succeed, the scope of survey should be limited to a specific water body or a small number of them. Preferably, the user group would be contacted while actually fishing the water body in question. This would eliminate anglers' lack of recognition or misidentification of the water fished. The study should canvas attitudes of anglers before and after a new regulation is initiated. The use of known users would provide higher reliability in responses and allow for evaluation of social desirability bias.

Despite likely overestimates of total use of wild trout waters determined from this study, other aspects of this study are pertinent to the existing regulations and future management decisions regarding wild trout waters. Angler opinions regarding the existing regulations are valid. The reduced support for future expansion of wild trout regulations suggests managers should evaluate waters on a case by case basis before proceeding. Most anglers who indicated they were displaced by the regulation, shifted to new waters compared to those who quit fishing or fished less frequently.

In our study, an estimated 29.6% of the survey respondents who fished wild trout waters indicated they were partially or totally displaced from those waters due to the regulation. The majority *(80%)* of these displaced anglers indicated they changed fishing locations but otherwise continued to fish. On the South Fork Payette River in 1992, 16% to 27% (mean 23%) of the anglers indicated they were less likely to fish the new wild trout regulation waters (Elle 1993). Angler effort dropped sharply on Crooked River (tributary to South Fork Salmon River) in 1994, the first year of the wild trout regulation. On both South Fork Payette and Crooked rivers, anglers moved to nearby hatchery supported waters (Elle 1993; Russ Kiefer, IDFG, personal communication).

Lewynsky (1986) suggested if a restricted harvest regulation had general public support, most anglers would accept the new regulation with a minority of anglers displaced from the fishery. Only four (5.1 %) of the surveyed anglers who reported being displaced from fishing wild trout waters indicated they stopped fishing altogether. The reasons for loss of these anglers probably includes lost harvest opportunity, increased regulation complexity, or the "loss" of their favorite fishing stream to special regulations, even though restrictions were minimal. And though reportedly due to implementation of wild trout regulations, some anglers may have dropped out for other reasons.

Results of our study indicate 84% of survey respondents favored or had no opinion regarding the 1992 wild trout regulation, and nearly 65% of the anglers indicated they did not change fishing habits on the waters in question. Support for future expansion of wild trout regulations to additional waters was lower compared to maintaining existing regulations. Lewynsky (1986) cautions that anglers may be prone to accept an existing regulation as the status quo or because they believe it is socially desirable. Sudman and Bradburn (1974), Chase and Godbey (1983), and Chase and Harada (1984) indicate social desirability can result in a positive response bias in public surveys. Acceptance of the status quo or social desirability bias may partly explain the differences between support for the existing waters compared to future expansion of wild trout regulations.

I based estimates of angler displacement on the percentage of anglers who reported fishing the wild trout regulation waters (anglers who do not fish these waters should not be affected by the restricted bag limit). If survey respondents over-reported the rate they fish these waters, then the impact to statewide license buyers is lower than estimated. Therefore, I regard the estimated angler displacement and reduced fishing activities as an upper bound of the level of impacts of wild trout regulation implementation.

Statewide, based on respondents to this survey, the impact to licensed anglers due to wild trout regulation implementation is small, with .3% (95% C.I. ± 0.4) who stopped fishing entirely and 1.3% (95% C.I. ± 0.8) who fished less often. The present and future impact of angler displacement should not be disregarded, however. While the reported number of license buyers lost due to this regulation is small, the anglers who fish less often may become future license buyer dropouts (Sanyal and McLaughlin 1993). Additionally, "lost" anglers probably represent parents who will no longer encourage or teach their children to fish. Based on national trends, any loss of active anglers should be a concern to management agencies. Idaho Fish and Game personnel should continue to increase information availability on where hatchery supported waters or 6 fish trout limits exist. Additional creative alternatives for harvest-oriented anglers need to be developed, such as stocking gravel ponds in areas where wild trout regulations may have displaced harvest-oriented anglers.

This survey attempted to assess the impact of wild trout regulations on angler's fishing habits the first year following implementation. While results have some potential biases, they do provide some insights on the immediate impact of these regulations on angler use. Results suggest the regulation may be effective in reducing exploitation of wild trout by displacing harvest-oriented anglers. Seventy-two percent of displaced anglers were harvest-oriented (prefer to keep a 6 fish limit). Elsewhere in Idaho, implementation of harvest restrictions has typically resulted in an immediate decline in angler use, followed by a gradual increase equal to or above pre-regulation use (Moore et al. 1979, Johnson and Bjornn 1978).

For the wild trout management strategy to be successful in the long term, displaced anglers will need to find alternative fishing sites. If the catch rate and/or size of fish in the fishery improves, new non-consumptive anglers may be recruited and/or current anglers may become less harvest-oriented. The ultimate affect of the regulation on wild trout populations and the fisheries in these streams will not be realized for some time.

RECOMMENDATIONS

1. Continue the "wild trout" program in the 1996-2000 Idaho Department of Fish and Game Fish Management Plan. In light of angler attitudes regarding future expansion, management should review new wild trout regulations on a case by case basis with a random survey.

2. Expansion of data from this survey provided major overestimates of angler use of wild trout waters. Future use of statewide surveys for assessing angler use or attitudes needs to address survey limitations which result in recall bias by participants. Major sources of error for consideration include:

   a. Time intervals for recall of information. Time intervals of 6 months or less are preferred.

b. Potential social desirability bias of anglers telling us what they think we want to hear needs to be addressed.
c. Participants' likely confusion with identifying specific water bodies.
d. Participants' likely confusion with identifying restrictive regulations.

3. Future displacement studies should be designed for long-term evaluations. Studies need to identify angling participants prior to regulation changes. Then a critical step includes follow-up evaluations of specific anglers' fishing habits for a longer period of time following regulations changes.

4. Where pre-regulation baseline data exists, angler use surveys should be conducted on wild trout streams five or more years after implementation of regulations to assess impact on total use.

ACKNOWLEDGEMENTS

Tom McArthur assisted with questionnaire development, sample selections, and data entry and analysis. His assistance with SYSTAT analysis was very helpful. Tony Lamansky and Rod Scarpella assisted with supervision of survey mailings and data entry. Numerous volunteers provided manpower for survey mailings and data entry.

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APPENDICES

Appendix A. Introduction and questionnaire use;; co assess angler displacement following implementation of wild trout regulations (2 fish bag limit) during 1992.

September 23, 1994

Dear Angler:

We are conducting a survey to evaluate angler attitudes on wild trout (two-fish bag limit) management. Your input through this questionnaire is important in determining future management decisions.

Based on angler opinions from a 1988 statewide survey, the Department increased emphasis on wild trout management in 1992. Part of this program included managing some rivers and streams with naturally-produced trout and a reduced bag limit of two (2) trout, with no restrictions on fish size or fishing tackle. No hatchery trout are released in these stream sections. The following questionnaire is designed to provide angler input on this management program for use in developing the next Five-Year Fish Management Plan for the period 1996-2000.

You have been selected from a sample of 1992 Idaho fishing license buyers. Please take time to answer the following questionnaire and return it in the prepaid return envelope. Your response is very important due to the limited number of anglers selected for this survey. If you have any questions please feel free to contact Steve Elle at (208) 465-8404. Your time and cooperation is greatly appreciated.

Sincerely,

Jerry M. Conley
Director

Enclosures

JOBXXAPB

Appendix A. (continued)

ANGLER SURVEY ON WILD TROUT

Question 1. How many members of your household (including yourself) fish? (Please enter number)_____

Question 2. Roughly how many days do you spend fishing each year? (Please check one)

1-3 Days a Year	_____
4-10 Days a Year	_____
11-20 Days a Year	_____
21-30 Days a Year	_____
31 Or More Days a Year	_____

Question 3. Check the statement that comes closest to describing your fishing habits in rivers and streams.

- o I generally keep the eating sized-trout I catch and try to get a limit.
- o I may keep one or two trout, but generally release most of the trout I catch in streams.
- o I only occasionally or never keep trout.

Question 4. What is your opinion on maintaining or expanding the number of rivers and streams with the two-fish bag limit regulations in the future?

Maintain number of rivers and streams: Favor_____ Oppose_____No opinion._____
Expand to new rivers and streams: Favor_____ Oppose_____No opinion_____

Question 5. The waters listed on the two next pages are the river and stream sections in Idaho managed under the two-fish bag limit regulation since 1992. Did you fish any of these streams during 1990 or 1991, prior to the start of the two-fish bag limit regulations in 1992?

If yes: Please check the box of the stream(s) you fished (left column). Record how many days you fished each stream (right column).

We know memory after three years is difficult, please provide your best recollection. (If you fished a stream listed but not in the described section, please do not check the box or list the days fished. We are only interested in the stream sections with a two-fish bag limit.)

Appendix A. (continued)

We used the following abbreviations in the table: tribs = tributaries, Cr = creek, R = river, S = south, N = north, E = east, Res = reservoir, Fk = fork, and MFSR = Middle Fork Salmon River.

Water	Descriotion	Days Fished
o Movie R	Mouth Meadow Cr downstream to Res	_______
o Spokane R	Stateline upstream to Post Falls Dam	_______
o Pend Oreille tribs	Gold Cr, Granite Cr, Grouse Cr, Lightning Cr, N. Gold Cr, Pack R, Rapid Lightning Cr	_______
o Priest Lake tribs	Beaver Cr, Granite Cr, Indian Cr, Kalispell Cr, Lion Cr, Two Mouth Cr	_______
o E Fk Potlatch R and tribs	East of Moscow)	_______
o Dworshak Res tribs	Breakfast Cr, Elk Cr, Little N Fk, Reeds Cr	_______
o N Fk Clearwater R tribs	(except Kelly Cr)	_______
o Lochsa R tribs	(except Crooked Fk Cr)	_______
o Crooked Fk Cr	From Brushy Fk Cr upstream and all tributaries including Brushy Fk Cr	_______
o Selway R tribs		_______
o Tenmile Cr	Tributary to S Fk Clearwater R	_______
o Johns Cr and tribs	Tributary to S Fk Clearwater R	_______
o Granite Cr	Tributary to Snake R (Hells Canyon)	_______
o Sheep Cr	Tributary to Snake R (Hells Canyon)	_______
o White Bird Cr	Tributary to Salmon R	_______
o Salmon R tribs	(Little Salmon R upstream to Horse Cr except Little Salmon R, and S Fk Salmon R)	_______
o Chamberlain Cr and tribs	Tributary to Salmon R	_______
o Salmon R	Mainstem and tribs upstream from Hell Roaring Cr (Stanley Basin)	_______
o Valley Cr	Upstream of Stanley Lake Cr	_______
o Camas Cr tribs	(MFSR)	_______

We used the following abbreviations in the table: tribs = tributaries, Cr = creek, R = river, S = south, N = north, E = east, Res = reservoir, Fk = fork, and MFSR = Middle Fork Salmon River.

	Water	Description	Days Fished
o	Indian Cr and tribs	(MFSR)From Tomahawk Cr upstream	
O	Loon Cr tribs	(MFSR)	
o	Marble Cr and tribs	(MFSR)From Prospect Cr upstream	
O	Pistol Cr and tribs	(MFSR)From Forty-five Cr upstream	
O	Sulphur Cr tribs	(MFSR)	
o	Rapid R and tribs	(MFSR)From Cabin Cr upstream	
O	Middle Fk Salmon R	Dagger Cr upstream to confluence Bear Valley and Marsh creeks	
0	Squaw Cr and tribs	Tributary to Payette R	
o	South Fk Payette R	From mouth IN Fk Payette R) upstream to Deadwood R or from Eight-mile Cr upstream to headwaters	
o	Bruneau R and tribs		–
o	Jarbidge R and tribs	(Owyhee County)	—
o	Snake R	Lower Salmon Falls Dam upstream to Upper Salmon Falls Dam	
o	Malad R	Mouth to Interstate 84 bridge (Near Bliss)	
o	Box Canyon Cr	(Near Twin Falls)	
o	Devils Corral Cr	(Near Twin Falls)	
o	Vinyard Cr	(Near Twin Falls)	
o	Little Wood R and tribs	Upstream from Baugh Creek	
o	Willow Cr'	Trib to Camas Cr (near Fairfield)	
0	Sublett Res tribs		
o	Rapid Cr	Trib to Portneuf R	
o	Fall R and tribs	Trib to Henrys Fork	

Appendix A. (continued)

If you did not fish any of the above listed rivers and streams, you are through with the survey. Please return the survey and thank you for your cooperation.

If you fished one or more of the streams listed, please answer the following questions.

Question 6. How has your fishing use changed on streams you checked in the above list as a result of the change in regulations in 1992 to a two-fish bag limit? (please select one)

- CI Stopped fishing these stream(s)
- Stopped fishing as much on these stream(s)
- Started fishing these stream(s)
- Started fishing more often on these stream(s)
- No change

Question 7. If you stooned fishino or stowed fishin[g] as much (from question 6) any of the streams you marked above because of the regulations, please check the box that best describes how your fishing habits changed. Where did you shift your "lost" fishing time? (Check one or more)

- Switched to nearby trout streams (within 10 miles) with the general six-fish limit a
- Switched to other trout fishing further away (more than 10 miles)
- Switched to hatchery planted waters (general regulations, six-fish limit)
- Switched to trout in lakes or reservoirs
- Switched to warmwater species
- Do not fish as many days as before
- Quit fishing entirely (stopped buying a license)

Question 8. Would you be willing to participate in a panel of anglers who would identify the strengths and weaknesses of the two-fish bag limit regulation and the wild trout management program in general? Yes_____ No_____

If you would like more information regarding the reasons for the two-fish bag limit and its application to Idaho waters, please contact the fisheries biologists in the regional offices of the Idaho Department of Fish and Game:

Panhandle Region	769-1414	Magic Valley Region	324-4350
Clearwater Region	743-6502	Southeast Region	232-4703
Southwest Region	465-8465	Upper Snake Region	525-7290
(From Boise)	887-6729	Salmon Region	756-2271
McCall Subregion	634-8137		

Again, thank you for your time in filling out this questionnaire.

ANNUAL PERFORMANCE REPORT

State of: Idaho

Grant No.: F-73-R-17. Fishery Research

Project No.: ,

Title: Wild Trout Investigations

Subproject No.: 2. Steelhead Exploitation Studies

Period covered: April 1. 1994 to March 31. 1995

ABSTRACT

Dingel-Johnson funding was used to coordinate regional field work and assist with data collection to evaluate angler exploitation of wild steelhead stocks in Idaho. Data was collected using snorkeling and creel census methods. The data collected was forwarded to management for analysis as part of a larger comprehensive look at steelhead exploitation on low, medium, and high angler use streams.

Author:

Steven Elle
Senior Fishery Research Biologist

ANNUAL PERFORMANCE REPORT

State of: Idaho Grant: F-73-R-17. Fishery Research

Project No.: 6 Title: Bull Trout Investigations

Subproject No.: 1. Rapid River Bull Trout Movement and Mortality Studies

Period covered: April 1. 1994 to March 31. 1995

ABSTRACT

Radio-tagged bull trout *Salvelinus confluentus* from Rapid River overwintered in Salmon River pools and runs from Riggins to Whitebird (about 50 km) similar to the 1992 to 1993 winter monitoring. Radio tracking throughout the winter indicated first upstream movement occurred in March with the initial rise in water temperature. Five of the seven radio-tagged fish moved upstream in the Salmon River and into Rapid River as water temperatures warmed to 10°C in May. Rapid River trap entry coincided with temperatures 10°C as in 1993.

Twenty-six percent of the 1993 outmigrants 2300 mm returned to Rapid River as consecutive year repeat spawners in 1994. This estimate represents a minimum value for repeat spawners because some fish can escape upstream without detection at the adult trap. The repeat spawners grew an average of 54 mm (11 mm to 107 mm) during the 7- to 9-month overwinter period. I detected no significant difference in mean growth and condition factor between repeat spawners marked with radio tags versus those with Floy and Passive Integrated Transponder (PIT) tags. In 1994, we captured no upstream migrant bull trout which were ≤ 250 mm at time of PIT tagging in fall 1993. These fish likely spend an additional 1 to 2 years in the Salmon River prior to maturing.

Fall outmigration of bull trout occurred primarily in September and October. Peak trap counts in late October coincided with rain and rising discharge but downstream trap facilities appeared to delay outmigration. I PIT-tagged 424 bull trout for future survival and aging validation studies. Incomplete downstream trapping precluded estimates of spawning survival.

Downstream trap data indicates up to 43% of migrating bull trout were not captured moving upstream at the adult weir in the spring. The discrepancy appears to be the result of a portion of upstream migrants which are not captured and some bull trout 2300 mm which are first time outmigrants from Rapid River. Thus, past upstream trap results may not reflect total upstream spawning migrants. Reconstruction of the upstream trap facilities in fall 1994 will result in complete trap counts in the future. The change will result in some difficulty in long-term monitoring due to incomplete trap counts in the past.

I adjusted the 1993 post-spawning mortality estimate for untagged bull trout using data for unmarked bull trout from the 1994 downstream trap. The adjusted estimate of 1993

spawning mortality ranges from 45 to 56%. The mortality estimate for radio-tagged bull trout during 1993 was within this range (47%).

A summary of findings from three years of study is presented.

Author:

Steven Elle
Senior Fishery Research Biologist

INTRODUCTION

Bull trout *Salvelinus confluentus* were petitioned for listing under the Endangered Species Act (ESA) in 1992. With the petition for listing has come increased emphasis on collecting life history and stock status information. Bull trout behavior and life history patterns make detailed studies difficult (Schill et al. 1994). Low population densities of bull trout (Schill 1992) add to the difficulty of population studies.

Radio telemetry can greatly improve our ability to study bull trout life history. During 1992 and 1993, studies were conducted on the Rapid River bull trout stock for migration, spawning, and overwintering behavior (Schill et al. 94, Elle et al. 1994). During 1992 and 1993, surgically implanted radio tags with external whip antennas were used for radio telemetry. Spawning mortality based on radio tag data appeared quite heavy during 1992 and 1993 at 67% and 47%, respectively. During 1993, mortality estimates for untagged adult bull trout was estimated at 21%. The mortality estimates for radio-tagged adults >300 mm exceeded estimates for untagged fish in 1993 (47% versus 21%). An error in statistical analysis led me to conclude no statistical difference existed between mortality of tagged versus untagged fish in 1993. Further analysis indicated the differences were in fact significantly different (Chi square test, $P < .05$).

There are other possible explanations for the discrepancy in mortality rates, however. Upstream migrants may bypass the adult trap through a sediment venturi pipe at the ladder (Rick Lowell, Rapid River Hatchery Superintendent, personal communication). Also, some bull trout > 300 mm may emigrate from Rapid River during the fall for the first time. The 1993 studies did not use marked fish to determine estimated mortality of untagged bull trout. Without marked fish, questions remained regarding the true survival of untagged adults.

No information exists on survival of fluvial bull trout from juvenile outmigration to spawning. The Rapid River salmon trap, with the closing of the sediment bypass pipe, represents an opportunity to collect survival data for very little money and effort. Steelhead research plans include maintaining outmigration trapping facilities in Rapid River in coming years.

OBJECTIVES

Research Goal: Provide sufficient life history data to maintain and restore bull trout for trophy fishing opportunities.

1. To estimate spawning mortality of bull trout in Rapid River.

2. To document timing and size of juvenile bull trout emigrants and continue survival estimates.

3. To estimate survival of juvenile bull trout from outmigration to spawning.

4. To assess winter movement patterns and migration timing by adult bull trout in Salmon River.

STUDY AREA

Rapid River is a fourth order tributary to the Little Salmon River near Riggins, Idaho (Figure 1). The study area is described in detail in Schill et al. (1994).

METHODS

Overwinter and Upstream Migration Tracking

Information from 1993 (Elle et al. 1994) indicated that the life of radio tags implanted during June the previous year may extend into the spring upstream migration the following year. I continued to monitor 12 radio-tagged bull trout which migrated out of Rapid River into the Little Salmon and Salmon rivers to monitor general winter and spring movement patterns. Project personnel completed fifteen ground surveys by vehicle from October 10, 1993 through June 7, 1994 categorizing the habitat types utilized by fish at all locations as pools, runs, or riffles (Bisson et al. 1982). Fish locations were recorded in relation to landmarks and highway mile markers to determine movement from prior surveys. I compared temperature information provided by the Bureau of Land Management for the Salmon River at Riggins and at the mouth of the Little Salmon River with bull trout upstream migration timing.

Adult Migration

Rapid River Fish Hatchery personnel annually maintain an upstream adult chinook salmon *Oncorhynchus tshawytscha* trap to monitor migration. During 1994, I again used these facilities to collect and enumerate adult bull trout during their upstream migration. Hatchery personnel recorded daily numbers of bull trout entering the upstream trap. Fish were anesthetized with MS-222. All bull trout were measured for total length to the nearest millimeter and weighed to the nearest 25 grams. Each fish was scanned for the presence of PIT tags implanted in downstream migrating bull trout during fall 1993. Each fish was inspected for the presence of radio or floy tags applied during the previous two years. A scale sample was collected from all fish. An adipose fin clip was used to mark all fish trapped. Following data collection, fish recovered in fresh water for 15 to 30 minutes and were then released into Rapid River upstream of the hatchery.

Repeat Spawner Bull Trout

I calculated growth (length in mm) and condition factor ($K = W/L^3$) for repeat spawners that had been tagged with radio transmitters versus with floy and PIT tags the previous year. I calculated growth and condition factors separately for bull trout <300 mm and >300 mm at the time of tagging in 1992 and 1993. Bull trout <300 mm are believed to be subadults, and therefore their growth may not be indicative of larger, spawning fish. I used a t-test to test

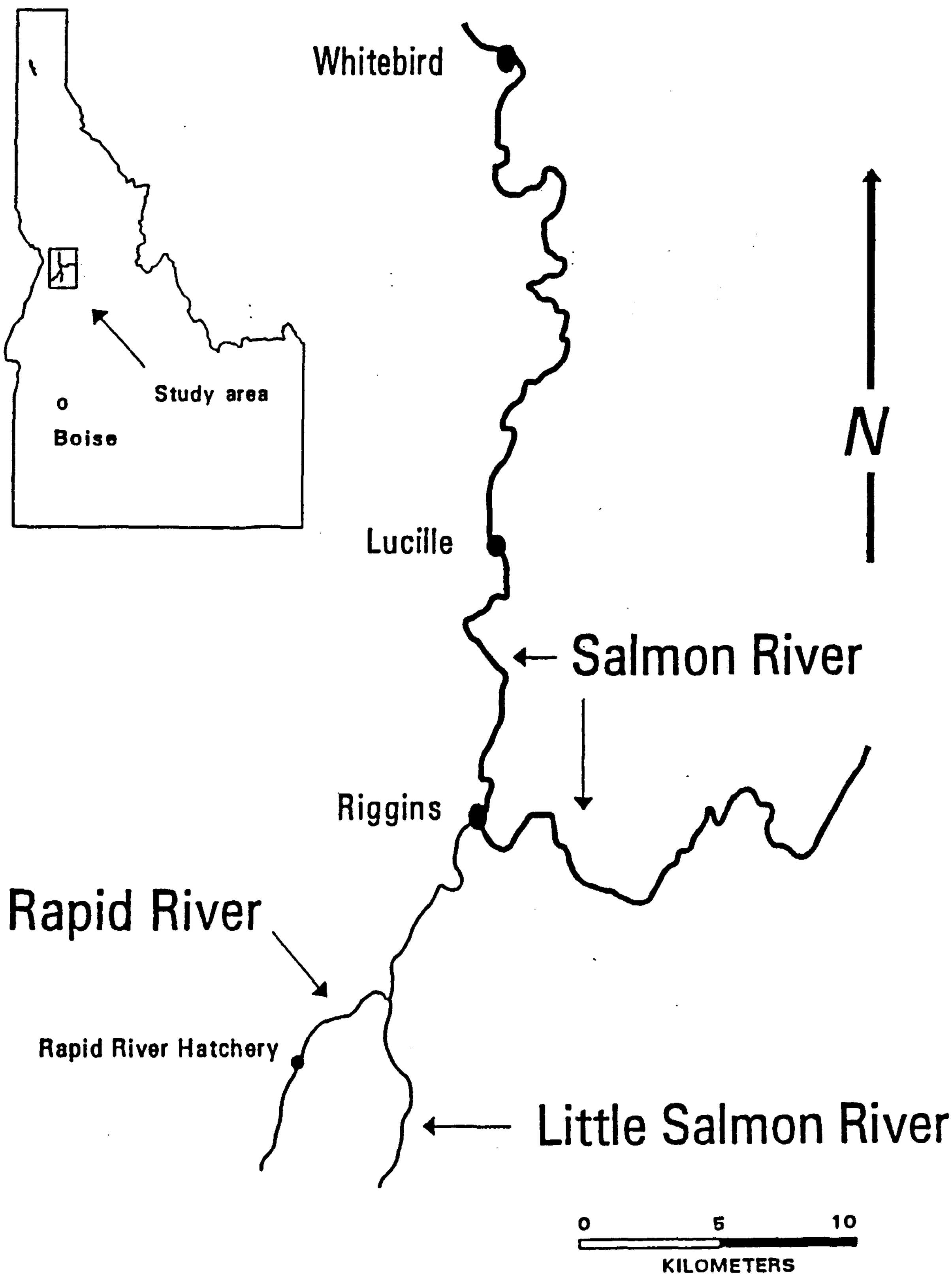


Figure 1. Study area for the Rapid River bull trout radio telemetry study.

differences in growth and condition factors between fish with radio tags versus non-radio-tagged fish (Zar 1984).

Downstream Trapning

A picket-style weir at Rapid River Fish Hatchery was used to collect downstream migrant salmonids. The design and dimensions are described in Elle et al. (1994). The trap was placed in Rapid River on July 26 and operated through October 29, when high water washed out the weir.

Biological data was recorded for all fish collected in the downstream trap. Fish were anesthetized using MS-222, identified, measured to the nearest millimeter (total length for bull trout and fork length for chinook and steelhead trout O. *mykiss),* and weighed to the nearest gram. Bull trout >300 mm captured at the upstream trap were adipose clipped. All downstream migrants >300 mm were examined for evidence of the prior marks. The ratio of adults with fin clips to fish without fin clips was used to account for those fish bypassing the upstream trap in the sediment pipe and fish which exit the drainage at >300 mm for the first time. All outmigrant bull trout were injected with PIT tags. Survival and growth of these individuals will be assessed by interrogating all bull trout in future Rapid River adult runs with PIT tag detectors.

Bull Trout-Brook Trout Hybridization

Brook trout *Salvelinus fontinalis* exist in many headwaters of the Salmon River and represent potential displacement of bull trout populations via hybridization, especially in the presence of habitat degradation (Cavendar 1978, Leary et al. 1991, Markel 1992). During fall 1993, we sampled 46 bull trout in Rapid River and 13 bull trout in West Pass Creek, tributary to the East Fork Salmon River, for visual identification of possible hybridization with brook trout. Visual characteristics used to identify brook trout included: 1) The presence of spots or vermiculations in the dorsal fin, 2) vermiculation marking on the dorsal portion of the body, and 3) coloration of the pelvic fins. Any fish with spots or vermiculation in the dorsal fin or body area or with tri-colored pelvic fins were called hybrids if they did not have distinct brook trout markings.

Adipose fin tissue was collected from all fish from which visual identifications were made. DNA analysis was conducted on the fin tissue by Robb Leary at University of Montana to validate the visual identification.

RESULTS

Overwinter and Upstream Migration Tracking

During the winter of 1993 to 1994 we followed 17 radio-tagged bull trout which outmigrated from Rapid River during fall 1993. Five of the tagged fish were harvested by sport fishermen. Four of the tags were monitored into the Uttle Salmon and Main Salmon rivers with no subsequent movement and we believe the fish shed the tags or died. An angler returned an additional tag after January 1 when statewide no-kill regulations for bull trout went into effect. He reportedly found the tag on the bottom of the Uttle Salmon River, an apparent shed tag or possible illegal sport harvest.

Bull trout locations were pinpointed on 96 occasions (63 prior to upstream migration) on the remaining seven tagged bull trout. Three of the fish had moved to their overwinter locations prior to our first tracking on October 10. The other fish moved to overwinter locations from October 20 through January 20. During the overwinter period, the fish were found in pool and run habitats 68% and 32% of the time, respectively. The fish generally remained within the same habitat unit with little movement (Table 1).

Upstream movement by 2 fish was first observed in March (Table 1). This movement coincided with the first noticeable increase in river temperatures from less than 1°C up to 4°C to 6°C. Fish 505 moved into the Uttle Salmon River and Rapid River during this period. Fish 344 also moved upstream 24 km but subsequently stopped in a pool in the Salmon River. Fish 344 and the remaining four bull trout showed a distinct upstream migration between April 27 and May 17. This movement coincided with river temperatures approaching or exceeding 10°C and increasing flows in the drainage.

Our locations of bull trout during the upstream movement indicated a shift in habitat types selected by the fish. During this movement period fish were located in pools, riffles, and runs 60%, 24%, and 16% of the time, respectively (N =25). Our locations during the periods of upstream movement did not distinguish if fish were moving through the habitats in which they were located or actually residing in those habitat types for extended periods of time.

Adult Migration

A total of 146 bull trout were captured during the 1994 spawning migration. The total falls within the range observed since 1973 and is similar to the number trapped during 1993 (Figure 2). Bull trout were captured from May 24 through August 2 (Figure 3). The majority of fish entered the trap by the end of June.

Water temperatures appear to have a major influence on adult migration in Rapid River. During the early part of the run, the number of bull trout trapped coincides with temperatures of 10°C or higher (Figure 3). The number trapped declined sharply following periods when temperatures fell below 10°C on May 27, June 6, and June 14. The other trend between temperature and migration indicates increased numbers of bull trout trapped with rising

Table 1. Bull trout overwinter and migration movement (listed in kilometers) and water temperatures coinciding with movement for 1993 and 1994. Temperatures listed in degrees centigrade.

Location dates	River temperature' franca)	Radio tag number 224	294	324	344	463	505	625
October 10	--	Trap	Lucille	Trap	0	0	0	Trap
October 20	-_	-10.0	-28.0	-8.3	0	-0.5	0	-8.3
November 09	0-2	0	0	-4.8	0	0.3	0	-16.0
December 01	0-1	0	-1.6	-4.0	0	0	0	-0.3
December 28	0-1	0	-0.5	0	0	-0.2	0	-7.3
January 20	0-1	0	3.2	0	0	0	0	-3.2
March 08	0-4	0	0	0.8	0	0	4.8°	_
March 31	4-8	0	0	NA`	24.2	0	8.0	0.2
April 07	8-9	0	0	NA	0.2	0	0	0.2
April 14	8-10	0	0	NA	0.2	0	0	-0.8
April27	8-10	0	1.1	NA	-0.8	-0.3	0	-0.2
May 10	8-12	0.8	33.8	NA	0	0	0	0
May 17	9-12	24.2°	8.0°	NA	8.0	12.9	0	14.5
May 24	9-12	4.8	4.8	NA	11.3	2.4°	0	12.9°
June 07	10-13	3.2	4.8	NA	NA	3.2	0	3.2

[a] River temperature range since prior fish location.
[b] Entered Little Salmon River.
[c] Not located. Trapped June 11, 1994.

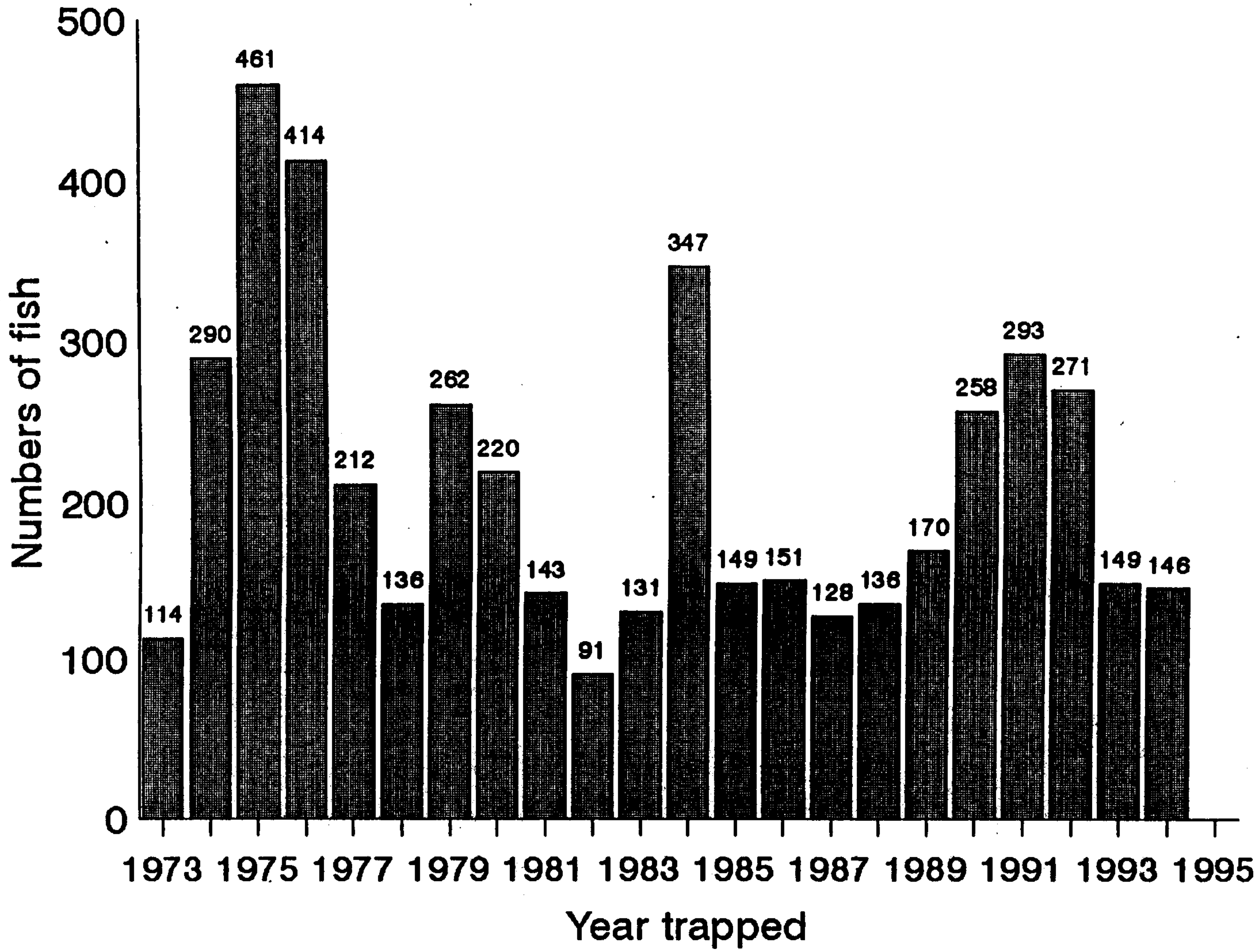
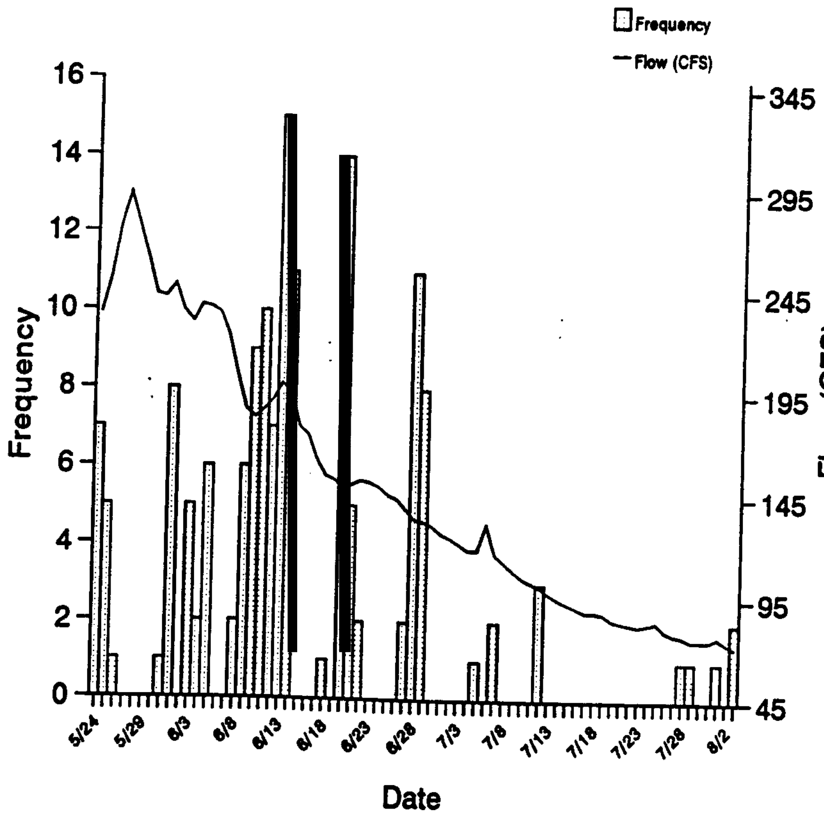


Figure 2. Numbers of adult bull trout moving upstream past the Rapid River weir. 1973 - 1994.



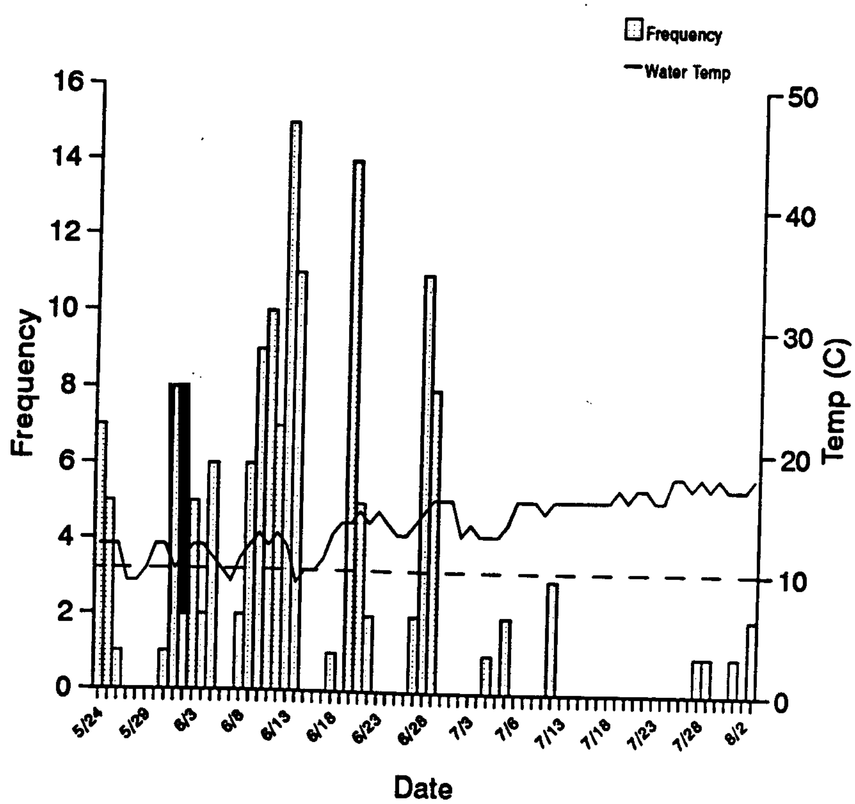


Figure 3. Trap counts of bull trout moving upstream past the Rapid River weir for 1994 with discharge and temperature data during trapping period.

temperatures. This trend is noticeable on June 18, June 27, July 6, and near the end of the trap entry period.

Size of bull trout captured ranged from 290 to 540 mm during 1994 (Figure 4). Fish X500 mm equalled 5.5% of the total trapped during 1994. The percentage of fish ≥500 mm in the spawning run has dropped from 12.2% and 7.4% during 1992 and 1993, respectively. Based on Chi-square analysis, the decline in size is significant at $P <.10$.

Repeat Spawner Bull Trout

I trapped 22 repeat spawner bull trout during 1994 (Appendix A). All repeat spawners > 300 mm at the time of tagging were captured as consecutive year spawners. I did not capture any of the fish which we radio-tagged in 1992 which were unaccounted for during 1993 overwinter radio tracking period in the main Salmon. Also, all fish tracked during the winter of 1993 to 1994 which exhibited spring movement entered the upstream trap.

Growth for repeat spawner bull trout ranged from 11 mm to 107 mm, but time at large varied for these individual fish. Bull trout (>300 mm when tagged) grew an average of 54 mm between the time of tagging and recapture (Table 2). Growth of bull trout <300 mm when tagged, averaged 105 mm between sampling dates. Smaller bull trout also had a lower condition factor compared with larger bull trout. Bull trout <300 mm are subadults.

During 1993, we PIT-tagged 189 bull trout <250 mm, 44 bull trout from 250 mm to 299 mm and 68 bull trout ≥300 mm. During 1994 we observed no recaptures from fish <250 mm. We estimate these fish to be 2 to 3 years old at outmigration based on scale analysis (Elle et al. 1994, Subproject 3 this report). Only 9% of the 250 mm to 299 mm size group (largely age 3 fish) were recaptured in the spring upstream migration in 1994. Twenty-six percent of the 1993 pit tagged bull trout X300 mm were recaptured during 1994.

Downstream Migration

I captured the first downstream migrant juvenile bull trout (<300 mm) July 27, one day after closing the trap. The outmigration occurred in three major periods; September 10 to 18, October 4 to 7, and October 27 to 28 (Figure 5). I continued to capture bull trout through October 29 when the trap failed in high water. During 1993, bull trout outmigration peaked when water temperatures dropped below 10°C. During 1994, no similar relationship was observed. As in 1993, fish staged in front of the weir in 1994, so peak trap counts are exaggerated.

I trapped a total of 456 bull trout (including 32 mortalities) in the downstream weir. The majority of the fish trapped were juveniles less than 300 mm. These fish were primarily age 2+ and 3+ (see Subproject 3). I PIT-tagged 424 bull trout ranging in length form 154 mm to 514 mm during 1994 (Figure 6) (Appendix B).

I captured 35 bull trout X300 mm in the downstream trap in 1994. Only 20 (57%) of these fish had an adipose clip which was applied to all fish captured in the upstream trap. The

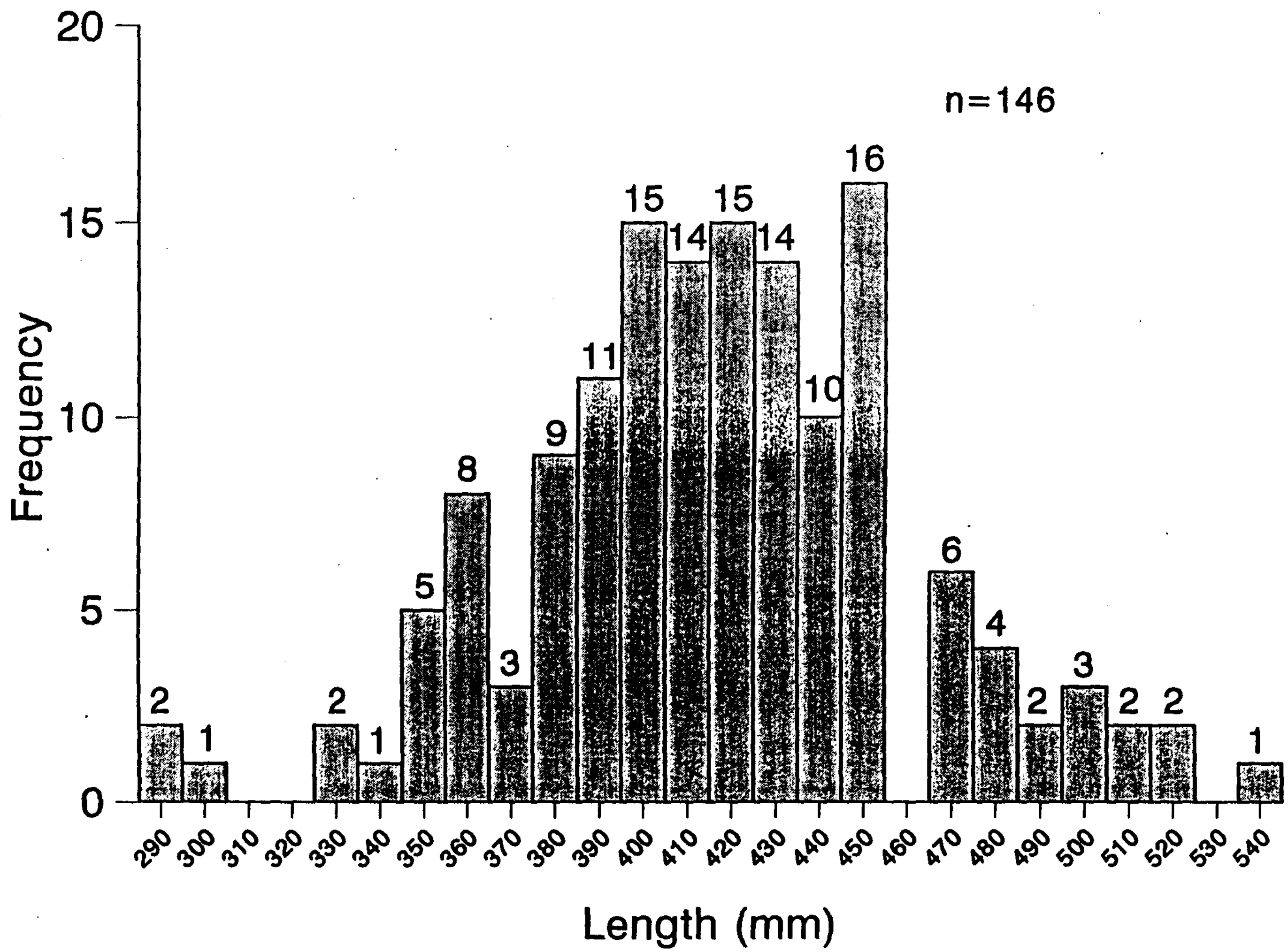


Figure 4. Length freqency of bull trout captured at the Rapid River upstream weir, 1994.

Table 2. Mean growth and condition factors for repeat spawning bull trout captured at Rapid River 1992-1994. Calculations made for radio tagged (including floy and PIT tags) and floy-PIT tagged fish. Juveniles (fish < 300 mm) at time of tagging separated from adults and subadults (fish > 300 mm).

Type of tag	Fish length at tagging	N	Length gain (mm)	Condition factor (x 10^{-6})
Radio	all	9	44.1 range = 11-107 SD = 26.6	10.49 range = 9.59-11.59 SD = 0.84
Floy-PIT	<300 mm	4	105.5 range = 92-115 SD = 9.68	9.39 range = 7.31-11.10 SD = 1.56
Floy-PIT	>300 mm	12	61.6 range = 41-97 SD = 14.30	10.62 range = 9.56-11.89 SD = 0.78

SD = Standard deviation.

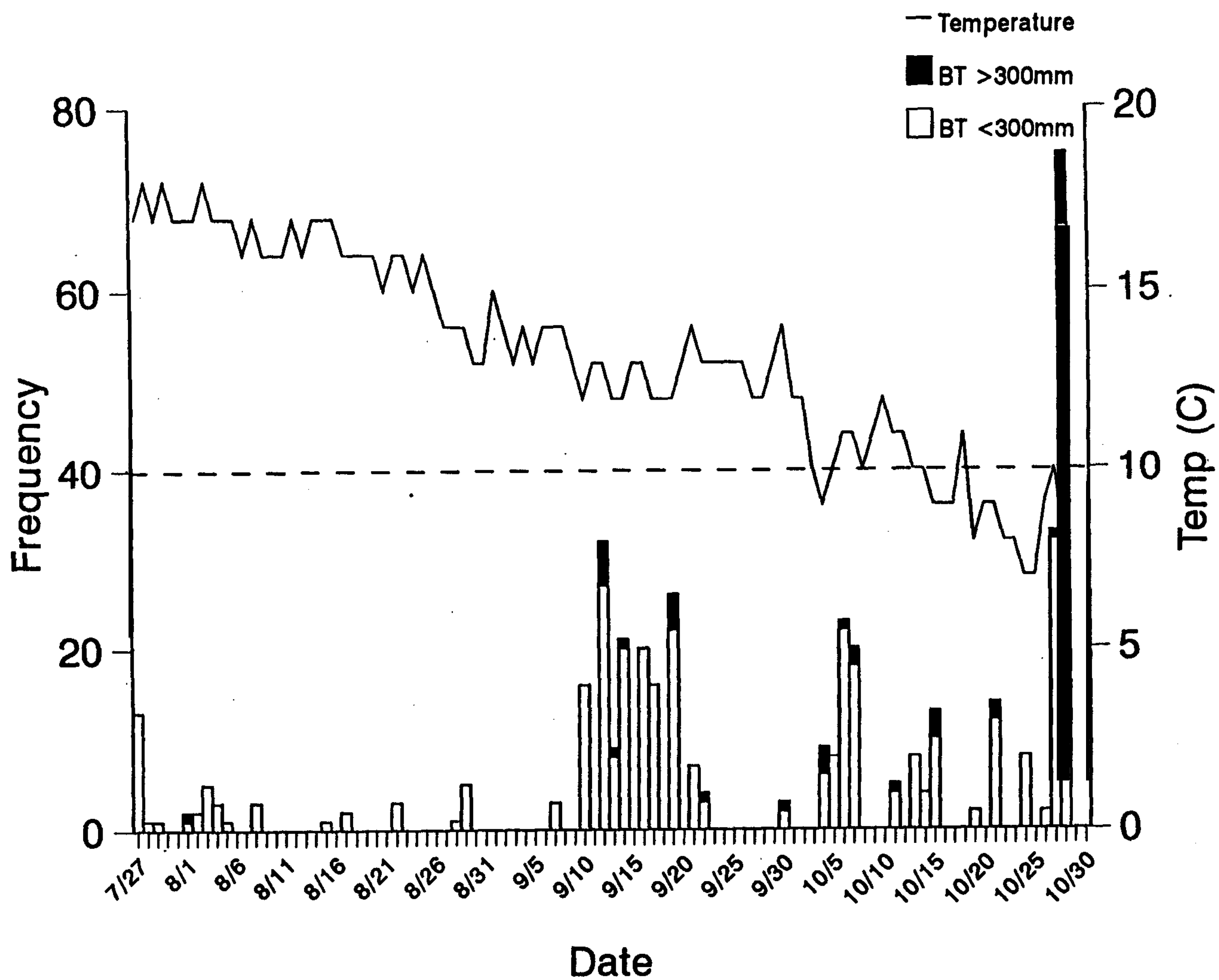


Figure 5. Frequency of bull trout migrating downstream in Rapid River compared with temperature by day, 1994.

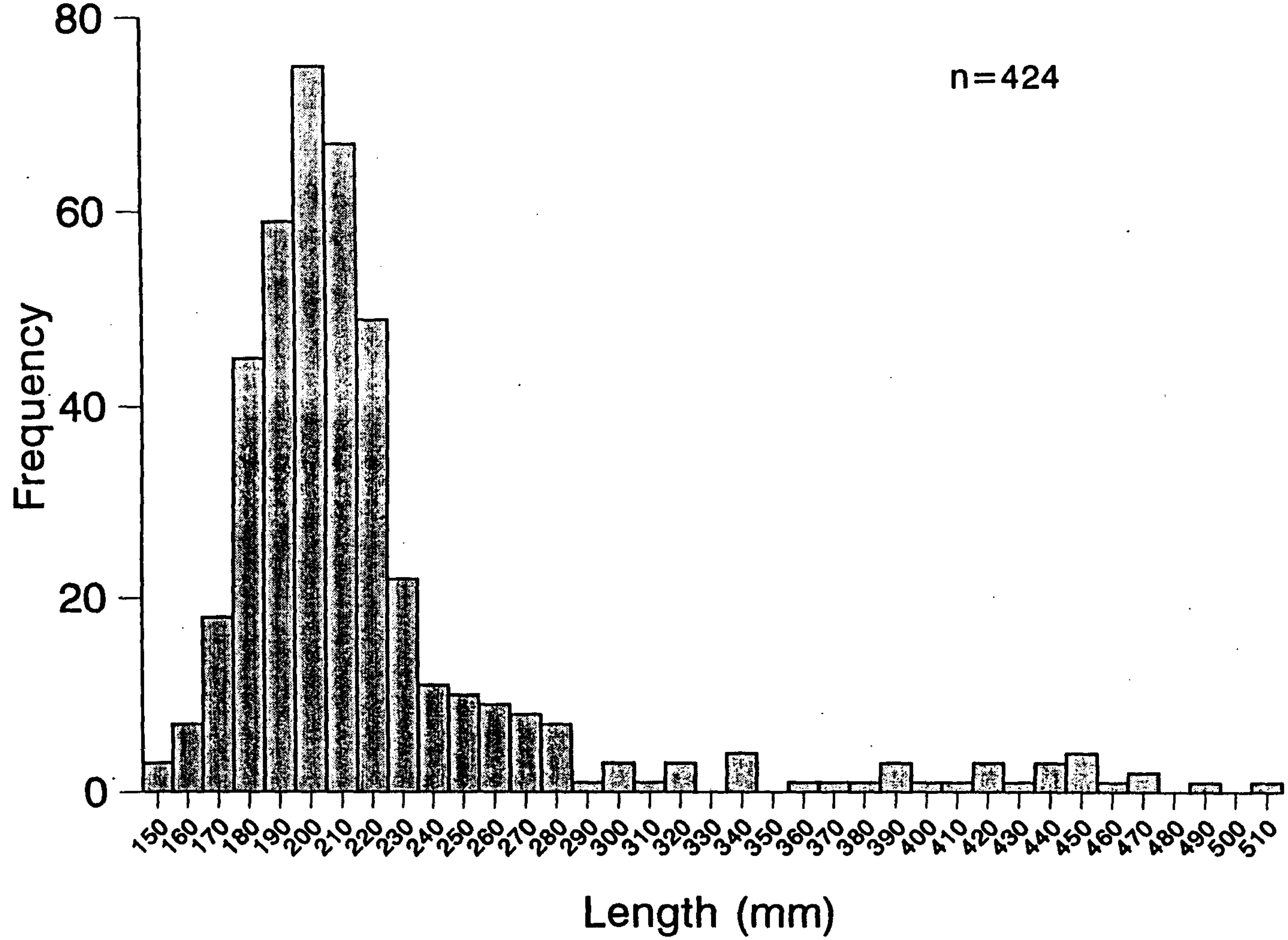


Figure 6. Length frequency of bull trout migrating downstream in Rapid River, 1994.

15 (43%) unmarked bull trout were smaller on average than those with adipose clips (Table 3). None of the fish <339 mm were adipose-clipped. Considering only fish 2340 mm, the percentage for marked and unmarked fish equals 69% and 31 %, respectively.

During 1993, we estimated spawning mortality was significantly different for radio-tagged bull trout >300 mm (46%) versus untagged fish (21%). During 1993, bull trout without radio tags were not otherwise marked. During 1993, the untagged outmigrant group were believed to include fish not counted at the upstream trap. The 1994 data suggest a large percentage of fall outmigrant bull trout >300 mm are not captured at the upstream trap. I multiplied the number of 1993 outmigrants 2300 mm (96 fish) by the 1994 percentage of marked fish for that size group (57.1 %) and divided by the total 1993 unmarked upstream migrants (115) for a calculated survival of 47.8%. The survival estimate for 1993 outmigrants 2340 mm equals 53.3% (81 1994 outmigrants times 69% marked fish for 1994 divided by 105 unmarked upstream migrants in 1993). The estimated mortality equals 1 minus survival or an estimated mortality of 52% for bull trout 2300 mm and 47% for fish 2340 mm in 1993. These estimates approximate the 46% mortality estimate for radio-tagged fish during 1993.

Several circumstances compromised our downstream trap results for evaluating mortality of adults during the 1994 spawning season. 1) Mink predation from October 8 through 14 resulted in the mortality of 22 bull trout. During this period, we closed the downstream trap during the night on October 11 to 14. After removing two mink, the trap mortalities ceased. 2) On October 22, a lack of communication between the trap tender and Rapid River Hatchery personnel resulted in the removal of 8 pickets from 1700 to 2100 hours when debris build-up threatened to undermine the trap structure. A group of bull trout > 300 mm had been observed upstream of the weir for 10 days prior to the breach. During the breach, an undetermined number of large bull trout moved downstream without detection. 3) On October 29, the downstream weir was washed out following three days of rain and rising water and debris levels. At this time the weir was pulled despite ongoing bull trout outmigration. Each of the events likely resulted in the loss of data regarding marked and unmarked adult bull trout. Due to incomplete trap records, we could not calculate a spawning mortality estimate.

Bull Trout-Brook Trout Hybridization

In Rapid River, I visually identified 40 bull trout, 3 brook trout, and 3 bull x brook trout hybrids out of the 46 fish sample. The genetic analysis by Robb Leary identified 42 bull trout, 3 brook trout, and 1 hybrid. Visual and DNA determinations matched for all fish except for two bull trout which I identified as hybrids due to vermiculations in the dorsal portion of the body. In West Pass Creek, tributary to the East Fork of Salmon River, visual inspections and DNA analysis each indicated 13 bull trout out of the 13 fish sample. For both samples combined, I made a correct assignment in 97% of the cases.

DISCUSSION

Idaho Fish and Game Commission closed bull trout to harvest in Idaho (except the Lake Pend Oreille and the lower Clark Fork River) January 1, 1994. I observed no change in numbers of adult fish at the upstream trap in 1994 compared to 1993. Between 1992 and 1994, the

Table 3. Size of fish and percentage with an adipose fin clip for bull trout x300 mm captured in the Rapid River downstream trap 1994.

Size range (mm)	Number marked		Number unmarked	
300-309	0	(--)	3	(100%)
310-319	0	(--)	0	(--)
320-329	0	(--)	3	(100%)
330-339	0	(--)	0	(--)
340-349	1	(25%)	3	(75%)
350-399	4	(67%)	2	(33%)
400-449	7	(70%)	3	(30%)
450+	8	(89%)	1	(11%)
Totals				
300-329	0	(--)	6	(100%)
340+	20	(69%)	9	(31%)
Grand mean	20	(57.1%)	15	(42.9%)

percent of bull trout over 500 mm has declined from 12.2% to 5.5% of the fish trapped, respectively. With harvest allowed through fall 1993, it is premature to expect a measurable increase in spawner numbers during 1994. Population response was documented in Lower Kananaskis Lake, Alberta, where increases of 150% in spawners and 95% in observed redds occurred in the second and third years following catch-and-release regulations (Stelfox 1995). An increase in the number of redds in Jacks Creek, tributary to Metolius River, was not observed until 3 years after the closure of tributaries to bull trout harvest. Harvest continued in Lake Billy Chinook, however, and may have limited population response to tributary harvest closure (Amy Stuart, Oregon Department of Fish and Wildlife, personal communication). Angling exploitation of 17% for Rapid River bull trout in the fall 1993 (Elle et al. 1994) plus angling harvest during other fishing seasons indicates the potential exists for increases in numbers of bull trout in the Rapid River population following elimination of sport harvest. If a positive population response to the no-kill harvest restriction in the Rapid River stock is going to occur, it should start to show increased numbers and size of fish trapped during 1995 or 1996.

Continuing to monitor the upstream trap counts for bull trout at the Rapid River chinook trap will provide a measure of the effectiveness of the no-harvest regulations for this population. The trap results should be reviewed with 1994 trap reconstruction in mind. Data from 1994 indicates up to 43% of upstream migrant bull trout may have escaped capture at the upstream weir in the past. Discussions with Rick Lowell, Rapid River Hatchery Superintendent, indicate fish may bypass the upstream trap through a 4 inch diameter sediment pipe which runs from the lower end of the fish ladder to the upstream face of the adult trap box. Future trap counts should include all upstream migrants. If the regulation is effective in enhancing the population, we should not only observe higher numbers of bull trout, but also an increased number and proportion of fish >500 mm. This will provide high quality estimates of juvenile survival from outmigration (our PIT-tagged fish) to their first spawning run. Such data is completely absent in the literature and would be a valuable portion of bull trout life history.

Data from radio and PIT-tagged bull trout marked during 1992 and 1993 indicate most repeat spawning fish return in consecutive years in Rapid River. Fraley and Shepard (1989) believed adfluvial bull trout stocks in the Flathead system in Montana were primarily alternate year spawners. Most studies have documented consecutive year repeat spawning in adfluvial populations in Oregon, Washington, and Alberta, Canada (Ratliff et al. 1994, Stelfox 1995, Allan 1980). Curt Kraemer (Washington Department of Wildlife, personal communication) believes Skagit River and Skykomish River bull trout populations are primarily consecutive year repeat spawners.

The presence of repeat spawners can greatly influence the reproductive capacity of a fish population. Repeat spawning females are generally larger and have more eggs than first time spawners. During 1994, 18 (12.3%) of the adult bull trout we captured were repeat spawners from 1993. The mean size of repeat spawning bull trout averaged 465 mm versus 420 mm for all fish captured in the upstream trap. Five of eight fish over 500 mm were repeat spawners. This group of fish was also susceptible to at least an additional year of angling harvest prior to regulation changes in January 1994. With the closure to harvest of bull trout, the percentage of repeat spawners may increase over time. Continued monitoring of upstream trapping facilities will document population response to regulation changes.

During 1993, downstream trapping data indicated a lower mortality of untagged bull trout (21%) compared to radio-tagged fish (46%) (Elle et al 1994). Although the original analysis indicated this difference in mortality was not statistically significant, subsequent analysis indicated it was significant (P <.05). In 1993, the untagged fish were not marked for positive identification, a crucial design error. We could not be sure that all untagged downstream migrants were counted at the upstream trap. With the error of not batch marking the non-radio-tagged fish in 1993, I was concerned the data showing a doubling of mortality rates from radio tagging could incorrectly result in restrictions on the use of surgically implanted radio tags if bull trout listing under ESA proceeds.

Downstream trapping in 1994 indicates up to 43% of the bull trout >300 mm were not detected at the upstream trap. By applying a correction factor for the percentage of unmarked to marked bull trout, the 1993 estimated mortality of unmarked bull trout closely approximates the 1993 radio tag estimate. A major data limitation is that the correction factor is based on incomplete downstream trap data. I assumed the ratio of marked bull trout captured is representative of the fish which outmigrated during breaches in the weir. Simply by chance, the ratio of marked to unmarked fish could be different during periods when we did not capture adults. However, the partial trap data is the best information we have to approximate the ratio of marked to unmarked bull trout >300 mm. Assuming use of the 1994 data to correct 1993 observation is appropriate, the data suggests little difference actually existed between mortality of bull trout with surgically implanted radio tags compared to untagged bull trout in 1993. These high spawning mortality rates could negate the benefits of the no harvest regulation initiated January 1994. If spawning mortality for bull trout is typically this high, benefits from harvest restrictions may be diminished.

The presence of the downstream weir delays downstream movement of bull trout. I observed up to 50 large (>300 mm) bull trout staging in front of the downstream trap during 1994 prior to a breach in the pickets. Ratliff et al. (1994) and Stelfox (1995) indicate similar behavior with downstream migrant bull trout and their resistance to enter trap facilities. Our observations agree with other studies, and bull trout downstream migration timing is affected by delay due to the presence of the weir. Conclusions about outmigrant timing are therefore limited. Future weir designs should include considerations for improved attraction into the trap facilities.

Bull trout hybridization with brook trout is considered a possible population threat (Cavendar 1978, Leary et al. 1991, Markel 1992). Brook trout reproduce at younger ages and are considered more tolerant of increased fine sediments and temperatures compared to bull trout. Hybridization between bull trout and brook produces a sterile F1 offspring. Thus hybridization coupled with habitat degradation can result in the displacement of bull trout populations. Brook trout were stocked throughout Idaho during the early 1900s including headwater lakes to Rapid River. During 1993, sampling in the headwater spawning areas documented bull x brook hybrids present in Rapid River. Long-term monitoring is needed to determine if brook trout are displacing bull trout populations. Such monitoring is dependent on accurate identification of two species and their hybrids. I was successful in identifying the hybrids by looking at fin characteristics the majority of the time. Chris Clancy (Montana Fish, Wildlife, Parks and Recreation, personal communication) has become accurate in the identification of bull x brook hybrids from 98% to 100% of the time as compared with DNA analysis. In general, any marking in the dorsal fin is the best characteristic in identifying hybrids. I recommend managers use such characteristics to determine the extent of hybridization when sampling bull trout stocks. If managers question their ability to visually identify brook trout and bull trout and their hybrids, tissue samples could easily be collected for DNA confirmation through the University of Montana.

Our limited sampling indicated little hybridization for bull trout in Rapid River and West Pass Creek, tributary to the East Fork Salmon River. Although brook trout and bull x brook trout hybrids were found in Rapid River, the majority of the fish sampled were pure bull trout. Our sample from West Pass Creek did not indicate any hybrids present. It was a small sample from only one tributary, however. Rieman and McIntyre (1993) believe the larger adfluvial or fluvial bull trout may have a competitive spawning advantage over the smaller brook trout.

RAPID RIVER RESEARCH EFFORTS 1992-1994 SUMMARY

Studies of Rapid River fluvial bull trout stocks during 1992 through 1994 have provided valuable life history data. This section provides a summary of the findings from the past three years, including results from Subproject 3 of this report.

1. Fluvial bull trout enter the upstream trap in Rapid River from late May to early August. The fish are not sexually mature when entering the trap. Upstream movement and trap entry appear to coincide with water temperatures of 10°C or more. Aging data indicates bull trout mature first at age 4+ in Rapid River, with the majority of adults 4+ to 6+ years old.

2. Adults spawned in late August and September during each year. Spawning locations were consistent over all three years despite widely different water flows between years. I detected no evidence of large spring-influenced zones at redd sites in Rapid River. Spawning occurred in limited geographical areas with pockets of gravel in Rapid River and one tributary.

3. Adults migrated downstream rapidly following spawning. Most bull trout leave the Rapid River headwater area within 1 to 3 weeks of spawning.

4. Post-spawning mortality ranged from 46% to 67% for radio-tagged bull trout. Estimates for 1993 untagged bull trout indicate a similar survival to radio-tagged fish.

5. Juvenile and adult outmigration occurs during late August through October. I have not conducted spring trapping and do not know the magnitude of spring versus fall outmigration. The majority of juvenile outmigrants are 180 mm to 290 mm and 2 to 3 years old.

6. Aging analysis indicates only partial agreement between scale and otolith age estimates for bull trout. Scales indicate lower ages compared to otoliths. Results from scale samples from marked bull trout during 1993 and 1994 failed to provide consistent age validation.

7. Following outmigration from Rapid River, most radio-tagged bull trout (≥80 mm) quickly entered the Main Salmon River to overwinter. Typically, little time was spent in the Little Salmon River. Most fish overwintered in the Salmon River within 50 km

downstream of the Little Salmon River. Maximum known movement to an overwinter site was 100 km downstream. Only one radio-tagged fish moved upstream of the mouth of the Little Salmon River once entering the Salmon River to overwinter.

8. Most fish overwintered in large pool or run habitats and showed little movement over the winter period.

9. Bull trout in Rapid River are consecutive year repeat spawners, yet they demonstrate considerable overwinter growth. Repeat spawners grew from 11 mm to 107 mm (mean = 54 mm) during the 7 to 9 month overwinter period.

10. Surgically implanted radio tags provided life history data not attainable through other methods. I observed no short-term mortality due to surgically implanted tags. Radio-tagged fish survived at similar rates compared to untagged bull trout.

11. The Rapid River spawning run contains a number of fish 300 mm to 450 mm which may be immature. Tag data suggests a portion of this sized bull trout enter Rapid River during the upstream migration, but subsequently migrate downstream prior to spawning during September.

RECOMMENDATIONS

1. Hatchery/management personnel should monitor bull trout numbers at all chinook traps to evaluate changes of bull trout numbers in response to no harvest regulations implemented January 1994. Total length data should be collected for all fish at all sites. Adults at Rapid River and East Fork should be interrogated with PIT tag detectors. Scale samples should be collected for all marked fish. All bull trout at trapping facilities should be PIT-tagged for future survival and growth information.

2. Monitoring for population response to no kill regulations should include the total number of bull trout returning annually, number and percent of fish > 500 mm, and percent of repeat spawners (where tagged fish are available).

3. Our surgical implantation of radio tags did not impact survival of adult bull trout. This methodology can be safely used for monitoring trout populations in Idaho.

4. Monitor Rapid River adult bull trout spawners for PIT tag returns for juvenile to adult survival in the Salmon River and associated growth estimates.

5. Managers should use absence of spots or markings in the dorsal fin to identify bull trout versus brook trout in population sampling. Bull trout x brook trout hybridization should be recorded in field sampling where distribution of these species overlap. In the event of uncertainty of identification of bull trout versus brook trout or the hybrid cross, managers can validate their field identification by collecting adipose fin samples and sending to University of Montana (Missoula) for analysis. Cost of sample is approximately $ 10.00 per fish.

6. Anadromous researchers conducting screw trap activities should attempt to estimate total bull trout emigration. Data could result in stock-recruit function. Scale samples would be required to apportion production to individual years for fish <300 mm. Samples of otoliths may be required for aging larger fish.
7. Anadromous researchers should continue to PIT tag a subsample to evaluate survival rates of bull trout. This should occur for East Fork Salmon River, Crooked River, and Rapid River.

ACKNOWLEDGEMENTS

Scott Springer conducted much of the trapping and fish handling operations during upstream and downstream trapping. Rod Scarpella provided valuable PIT tag training and file management. Rod also assisted with downstream weir construction and operation. Tony Lamansky completed ground radio tracking of bull trout during spring 1994 and worked on data summary and report figures. Rapid River Fish Hatchery personnel assisted with many phases of the study and also provided living quarters for research staff.

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APPENDICES

Appendix A. Comparison of bull trout size and growth for repeat spawners captured at Rapid River upstream weir 1992-1994. Comparisons for fish with radio tags versus floy and pit tags. Condition factors are for fish at the time of recapture during upstream migration.

Tag[1]	Date collected			Length (mm)				Condition factor[2]
type	1992	1993	1994	1992	1993	1994		Growth($x10^{-6}$)
radio	05/27	07/06		360	467		107	11.59
radio	06/01	06/28		520	564		44	9.59
radio	05/26	07/21		569	600		31	10.35
F-P		09/22	06/01		375	424	49	9.71
radio		09/29	06/04		486	529	43	10.47
F-P		09/22	06/08		418	489	71	11.76
F-P		10/11	06/09		456	518	62	10.83
F-P		09/21	06/09		447	500	53	9.60
F-P		09/29	06/10		393	445	52	10.78
F-P		09/21	06/10		337	405	68	11.29
radio		10/15	06/10		405	434	29	11.62
F-P		09/21	06/11		360	415	55	11.89
radio		09/21	06/11		465	498	33	11.13
F-P		09/21	06/13		330	427	97	10.28
F-P		09/22	06/13		476	540	64	10.80
radio		09/29	06/13		386	440	54	10.10
F-P		09/22	06/20		432	490	58	9.56
F-P		09/22	06/20		355	396	41	10.47
F-P		09/22	06/20		253	360	107	9.65
F-P		09/22	06/21		290	398	108	11.10
radio		10/13	06/21		467	478	11	9.15
F-P		09/29	06/28		355	424	69	10.50
F-P		09/22	06/29		278	370	92	7.31
F-P		09/22	07/12		266	381	115	9.49
radio		10/13	06/18		468	513	45	10.37

[1] Type of tag was radio (R) and floy/PIT tag or floy/PIT tag (F-P)
[2] Condition factor as a repeat spawner one year following tag placement.

Appendix B. PIT tag data files for bull trout captured at Rapid River, fall 1994.

Data	PIT-tag number	Length	Weight	Mark	Scale sample number	Comments
07/27/94	7F7D37121B	210	76	AD	94-A-5	
07/27/94	7F780F116D	220	102	AD	94-A-4	Last digit of PIT tag code may be 3
07/27/94	7F780F6A19	225	100	AD	94-A-7	
07/27/94	7F7D280663	189	48	AD	94-A-8	
07/27/94	7F7D285503	194	60	AD	94-A-9	
07/27/94	7F7D2C2C2E	190	54	AD	94-A-10	
07/27/94	7F780F1055	181	48	AD	94-A-11	
07/27/94	7F7D33790C	200	66	AD	94-A-12	
07/27/94	7F7D2C0135	231	104	AD	94-A-13	
07/27/94	7F7D4A212B	209	72	AD	94-A-14	
07/27/94	7F7D280827	206	74	AD	94-A-15	
07/27/94	7P7D476D3C	202	72	AD	94-A-16	
07/27/94	7F7D2B2011	194	64	AD	94-A-17	
07/28/94	7F7BOF781B	222	90	0	94-A-18	
07/29/94	7F7D281068	225	84	0	94-A-i9	
08/01/94	7F780F0153	221	92	0	94-A-20	
08/01/94	7F72073709	320	275	0	94-A-21	
08/02/94	7F7D7C1C52	212	79	0	94-A-22	
08/02/94	7F7D45517C	209	74	0	94-A-23	
08/03/94	7F7D4C4005	216	89	0	94-A-25	
08/03/94	7F7D454D72	154	30	0	94-A-26	
08/03/94	7F7D237846	204	63	0	94-A-27	
08/03/94	7F7D3EOD1F	194	57	0	94-A-28	
08/03/94	7F7B0A785E	189	54	0	94-A-29	
08/04/94	7F7D356A1F	218	86	0	94-A-30	
08/04/94	7F7D286674	203	70	O	94-A-31	
08/04/94	7F7D367020	183	46	0	94-A-32	
08/05/94	7F7D2C2662	268	170	0	94-A-33	
08/08/94	7P7D2A7370	197	64	0	94-A-34	
08/08/94	7F7D283840	200	60	0	.94-A-35	
08/08/94	7F7D384829	185	60	0	94-A-36	
08/15/94	7F7D363434	190	54	0	94-A-37	
08/17/94	7F7D2C3768	219	72	0	94-A-38	
08/17/94	7F7D366151	212	76	0	94-A-39	
08/22/94	7F7D337037	210	68	0	94-A-40	
08/22/94	7F7D51516C	222	84	0	94-A-41	
08/22/94	7P7D28584F	197	56	0	94-A-42	
08/29/94	7F780E5F45	211	56	0	94-A-43	
08/29/94	7F7D3A4862	212	52	0	94-A-44	
08/29/94	7F7B0A1C58	170	28	0	94-A-45	
08/29/94	7F7D186213	206	56	0	94-A-46A	
08/28/94	7F7BOF705F	175	40	0	94-A-46B	
08/29/94	7F7D354C18	200	60	0	94-A-47	
09/07/94	7F780F1852	188	56	0	94-A-48	
09/07/94	7F7D3E1F28	192	54	0	94-A-49	

Appendix B. Continued.

Date	PIT-tag number	Length	Weight	Mark	Scale sample number	Comments
09/07/94	7F7D1B5335	175	46	0	94-A-50	
09/10/94	7F7D3E215B	171	40	0	94-A-51	
09/10/94	7F7D3F374A	240	115	0	94-A-52	
09/10/94	7F7D3E3464	185	50	0	94-A-53	
09/10/94	7F7D38426D	210	80	0	94-A-54	
09/10/94	7F7B0A182B	213	80	0	94-A-55	
09/10/94	7F7D3F652C	220	76	0	94-A-56	
09/10/94	7F7D314554	211	76	0	94-A-57	
09/10/94	7F7D3F7367	186	54	0	94-A-58	
09/10/94	7F7D1B3013	204	72	0	94-A-59	
09/10/94	7F7D467540	175	46	0	94-A-61	
09/10/94	7F7D3E1D69	201	68	0	94-A-62	
09/10/94	7F7D2B7F1D	220	86	0	94-A-63	
09/10/94	7F7D3A4573	185	54	0	94-A-64	
09/10/94	7F7D3F323D	185	52	0	94-A-65	
09/10/94	7F7D7F606B	193	62	0	94-A-66	
09/10/94	7F7D3F3663	287	180	0	94-A-67	
09/12/94	7F7B0F622A	190	50	0	94-A-68	
09/12/94	7F7D3E2470	217	76	0	94-A-69.	
09/12/94	7F7B082276	264	140	0	94-A-70	
09/12/94	7F7E6A3B3E	226	96	0	94-A-71	
09/12/94	7F7D2C2751	215	88	0	94-A-72	
09/12/94	7F7D2C0658	160	32	0	94-A-73	
09/12/94	7F7D3F4B07	211	72	0	94-A-74	
09/12/94	7F7B0E6F45	196	64	0	94-A-75	
09/12/94	7F7D28674A	197	62	0	94-A-76	
09/12/94	7F7D3E1843	184	54	0	94-A-77	
09/12/94	7F7B08561B	206	64	0	94-A-78	
09/12/94	7F7D487075	162	34	0	94-A-79	
09/12/94	7F7D7F6B6E	262	135	0	94-A-80	
09/12/94	7F7B0A031B	210	68	0	94-A-81	
09/12/94	7F7D3D7D1E	215	82	0	94-A-82	
09/12/94	7F7D371756	250	116	0	94-A-83	
09/12/94	7F7D384210	273	160	0	94-A-84	
09/12/94	7F7D39060D	190	56	0	94-A-85	
09/12/94	7F7D2B6A02	199	68	0	94-A-86	
09/12/94	7F7D3E322A	302	210	0	94-A-87A	
09/12/94	7F7D367304	200	66	0	94-A-87B	
09/12/94	7F7B0F115F	221	96	0	94-A-88	
09/12/94	7F7B0F2B65	211	82	0	94-A-89	
09/12/94	7F7D3E1F1C	243	110	0	94-A-90	
09/12/94	7F7D2B4821	205	64	0	94-A-91	
09/12/94	7F7D38402A	308	210	0	94-A-92	
09/12/94	7F7B0A074D	190	46	0	94-A-93	
09/12/94	7F7D28155C	176	34	0	94-A-94	
09/12/94	7F7D38462D	279	170	0	94-A-95	

Appendix S. Continued.

Date	PIT-tag number	Length	Weight	ark	Scale sample number	Comments
09/12/94	7F7D7F6967	421	570	AD	0	
09/12/94	7F780F7A53	401	470	0	94-A-96	
09/12/94	7F78102730	463	745	AD	0	
09/13/94	7F7D301E49	191	58	0	94-A-97	
09/13/94	7F7D356804	252	128	0	94-A-98	
09/13/94	7F7D3E3067	211,	76	0	94-A-99	
09/13/94	7F7D356975	215	76	0	94-A-100	
09/13/94	7F7D3F2A68	221	78	0	94-A-101	
09/13/94	7F7D355D41	206	66	0	94-A-102	
09/13/94	7F7D3E322D	459	745	0	0	
09/13/94	7F78100514	160	34	0	94-A-103	
09/13/94	7F7D2A7C3D	239	98	0	94-A-104	
09/14/94	7F7D3E1732	217	82	0	94-A-105	
09/14/94	7F7D36683C	204	65	0	94-A-106	
09/14/94	7F7D3F6D40	272	155	0	94-A-107	
09/14/94	7F730F4A01	217	84	0	94-A-108	
09/14/94	7F7D363024	199	62	0	94-A-109	
09/14/94	7F7D2A7A46	225	96	0	94-A-110	
09/14/94	7F7D370346	207	72	0	94-A-Ill	
09/14/94	7F7B09022D	215	76	0	94-A-112	
09/14/94	7F7B0E4A33	225	100	0	94-A-113	
09/14/94	7F7D3F6A31	220	84	0	94-A-114	
D9/14/94	7F7D1E6D72	206	72	0	94-A-115	
09/14/94	7F7D2C303E	210	74	0	94-A-116	
09/14/94	7F7B0A113F	200	66	0	94-A-117	
D9/14/94	7F7D3E1608	230	92	0	94-A-118	
D9/14/94	7F7D367023	208	68	0	94-A-119	
D9/14/94	7F7D28153F	224	94	0	94-A-120	
)9/14/94	7F7B0F304F	395	51(510?)	AD	0	
)9/14/94	7F78102E5E	203	64	0	94-A-121	
)9/14/94	7F7D3F2F2B	187	62	0	94-A-122	
)9/14/94	7F7D3E253F	245	130	0	94-A-123	
)9/14/94	7F7D3E3425	225	84	0	94-A-124	
)9/16/94	7F7D286E44	197	60	0	94-A-125	
)9/16/94	7F7D366C28	221	82	0	94-A-126	
)9/16/94	7F7D371418	210	76	0	94-A-128	
)9/16/94	7F7D2A7DSA	234	108	0	94-A-129	
)9/16/94	7F7D366436	221	80	0	94-A-130	
)9/16/94	7F7D3E3315	170	36	0	94-A-131	
)9/16/94	7F7D1E6E17	200	64	0	94-A-132	
)9/16/94	7F7D38444F	200	64	0	94-A-133	
)9/16/94	7F780F3D4A	203	72	0	94-A-135	
)9/16/94	7F78080E6F	201	70	0	94-A-136	
19/16/94	7F7D185946	210	72	0	94-A-137	
19/16/94	7F7D467521	218	72	0	94-A-138	
19/16/94	7F7D45471B	210	78	0	94-A-139	

Appendix B. Continued.

Date	PIT-tag number	Length	Weight	Mark	Scale sample number	Comments
09/16/94	7F7D3F646B	203	66	0	94-A-141	
09/16/94	7F7D3E261A	215	72	0	94-1-142	
09/16/94	7F7D3F3676	190	56	0	94-A-143	
09/16/94	7F7D281412	193	68	0	94-1-144	
09/16/94	7F7D2B1649	195	62	0	94-A-145	
09/16/94	7F730A361D	191	54	0	94-A-146	
09/17/94	7F7D3F6E59	216	72	0	94-A-148	
09/17/94	7F7D2B6936	230	96	0	94-1-149	
09/17/94	7F720F5338	190	62	0	94-A-150	
09/17/94	7F7D2A7D05	194	56	0	94-A-151	
09/17/94	7F7B101350	180	40	0	94-1-152	
09/17/94	7F7D37121C	263	126	0	94-1-153	
09/17/94	7F7D2B3765	220	72	0	94-A-154	
09/17/94	7F7D3F3555	220	86	0	94-A-155	
09/17/94	7F7D2C2C4E	179	42	0	94-A-156	
09/17/94	7F7D3E154A	215	72	0	94-1-157	
09/17/94	7F7D356470	216	80	0	94-1-158	
09/17/94	7F750F6516	202	62	0	94-A-159'	
09/17/94	7F780F661C	201	60	0	94-A-160	
09/17/94	7F7D3E1758	222	76	0	94-A-161	
09/17/94	7F7D2B5A2F	200	72	0	94-A-162	
09/17/94	7F7D3E2103	182	44	0	94-A-163	
09/19/94	7F7D3E263B	204	64	0	94-A-164	
09/19/94	7F780F6C52	205	68	0	94-A-165	
09/19/94	7F7D3F697F	244	108	0	94-1-166	
09/19/94	7F7D38471A	212	80	0	94-A-167	
09/19/94	7F7D354729	204	62	0	94-A-168	
09/19/94	7F7E6BOF7D	.232	98	0	94-A-169	
09/19/94	7F7D2C2D21	208	74	0	94-A-170	
09/19/94	7F7D7F6F2B	224	88	0	94-A-171	
09/19/94	7F7D366D69	217	78	0	94-A-172	
09/19/94	7F7D3F6466	210	72	0	94-A-173	
09/19/94	7F7D2A732D	236	100	0	94-A-174	
09/19/94	7F7D336268	435	670	AD	0	
09/19/94	7F7D2C483E	440	654	AD	0	
09/19/94	7F7D2A255D	450	650	AD	0	
09/19/94	7F7BOE3A6D	472	760	AD	0	
09/19/94	7F7D3F5853	202	70	0	94-A-175	
09/19/94	7F7D3E265C	239	106	0	94-1-176	
09/19/94	7F780F616F	223	80	0	94-A-177	
09/19/94	7F7D2CO32D	210	66	0	94-A-178	
09/19/94	7F7D2A7415	220	82	0	94-A-179	
09/19/94	7F780F0800	226	98	0	94-A-180	
09/19/94	7F7D2B7F3E	250	130	0	94-A-181	
09/19/94	7F7D354B64	227	86	0	94-A-182	

Appendix B. Continued

Data	PIT-tag number	Length	Weight	Mark	Scale sample number	Comments
09/19/94	7F7D3A3966	211	78	0	94-A-184	
09/19/94	7F7D286A3E	184	52	0	94-A-185	
09/21/94	7F7D1E7363	193	56	0	94-1-186	
09/21/94	7F7D283465	215	78	0	94-1-187	
09/21/94	7P7D3E3368	205	62	0	94-A-188	
09/21/94	7F7D366466	196	58	0	94-1-189	
09/21/94	7F73067675	206	70	0	94-A-190	
09/21/94	7F7D2C2903	205	72	0	94-A-191	
09/21/94	7F7D3F6A53	210	70	0	94-A-192	
09/22/94	7F7D7F691A	490	930	AD	0	
09/22/94	7F7D3F3938	275	170	0	94-1-194	
09/22/94	7F7D370414	185	44	0	94-A-195	
09/22/94	7F7D3E1F27	181	48	0	94-1-196	
09/30/94	7F7D366C2A	226	90	0	94-A-197	
09/30/94	7F7D380C25	285	170	0	94-A-198	
09/30/94	7F7D3A493D	455	725	AD	0	
10/04/94	7F78116E5F	220	86	0	94-1-199	
10/04/94	7F7D2B1128	227	92	0	94-A-200	
10/04/94	7F7D2A7307	179	52	0	94-A-201	
10/04/94	7F7D370278	214	72	0	94-A-202	
10/04/94	7F7D113924	200	64	0	94-A-203	
10/04/94	7F78086F55	188	58	0	94-A-204	
10/04/94	7F7B0A4910	393	410	AD	0	
10/04/94	7F7D3A4223	514	1050	AD	0	
10/04/94	7F7D3F6856	415	605	AD	0	
10/05/94	7F7D451E57	233	88	0	94-A-205	
10/05/94	7F7807725D	172	38	0	94-A-206	
10/05/94	7F7D365F79	193	58	0	94-A-207	
10/05/94	7F7D286676	206	70	0	94-A-208	
10/05/94	7F7D44642C	183	43	0	94-A-209	
10/05/94	7F7D7F6000	211	66	0	94-A-210	
10/05/94	7F78083073	216	75	0	94-A-211	
10/05/94	7F78102525	220	84	0	94-A-212	
10/06/94	7F7D280760	205	60	0	94-A-213	
10/06/94	7F78101C3E	441	610	AD	0	
10/06/94	7F7D36317C	258	130	0	94-A-214	
10/06/94	7F7D4C257A	197	53	0	94-A-215	
10/06/94	7F7D2C0224	206	63	0	94-A-216	
10/06/94	7F7E68744F	222	78	0	94-A-217	
10/06/94	7F7809271C	281	170	0	94-A-218	
10/06/94	7F7D451D03	183	42	0	94-A-221	
10/06/94	7F7D28665F	215	70	0	94-A-222	
10/06/94	7F7D3E011C	204	62	0	94-A-223	
10/06/94	7F7D3E285C	198	56	0	94-A-224	
10/06/94	7F7D284A0E	283	165	0	94-A-225	

Appendix B. Continued.

Date	PIT-tag number	Lenath	Weiaht	Mark	Scale sample numbe^r	Comments
10/06/94	7F7D7F731A	238	108	0	94-A-226	
10/06/94	7F7D287346	185	46	0	94-A-227	
10/06/94	7F7B072F31	195	56	0	94-A-228	
10/06/94	7F7D367B47	216	72	0	94-A-229	
10/06/94	7F7309375E	200	56	0	94-A-230-	
10/06/94	7F7D445B71	250	110	0	94-A-231	
10/06/94	7F7D7F6A61	163	32	0	94-A-232	
10/06/94	7F780E4A46	175	40	0	94-A-233	
10/06/94	7F7D2B7A28	267	150	0	94-A-234	
10/06/94	7T7D28684B	235	95	0	94-A-235	
10/06/94	7F7D3F3C40	180	44	0	94-A-236	
10/07/94	7F7E686A0A	256	130	0	94-A-237	
10/07/94	7F7D42181D	243	120	0	94-A-238	
10/07/94	7F7D3E2E73	260	126	0	94-A-239	
10/07/94	7F7D414857	205	.62	0	94-A-240	
10/07/94	7F7D3E3702	206	70	0	94-A-241	
10/07/94	7F7D3E3055	272	150	0	94-A-242	
10/07/94	7F7D361811	242	106	0	94-A-243	
10/07/94	7F7D2B0061	320	280	0	94-A-244	
10/07/94	7F780F680C	220	71	0	94-A-245	
10/07/94	7F7D7F5903	231	90	0	94-A-246	
10/07/94	7F7D287719	239	96	0	94-A-247	
10/07/94	7F7D370D62	191	48	0	94-A-248	
10/07/94	7F7D2B7765	218	74	0	94-A-249	
10/07/94	7F7D2C4D79	194	52	8	94-A-250	
10/07/94	7F7D280F4A	349	295	AD	0	
10/07/94	7F7808066D	230	92	0	94-A-251	
10/07/94	7F7D36793F	177	42	0	94-A-252	
10/07/94	7F7D2B6240	270	140	0	94-A-253	
10/07/94	7F7D2B5577	179	44	0	94-A-254	
10/07/94	7F7D2C3523	227	86	0	94-A-255	
10/11/94	7F780E793E	390	455	AD	0	
10/11/94	7F7D38474B	279	165	0	94-A-256	
10/11/94	7F7D371268	162	40	0	94-A-257	
10/11/94	7F7D18660A	162	38	0	94-A-258	
10/11/94	7F7D367D17	197	58	0	94-A-'259	
10/13/94	7F730E5115	225	82	0	94-A-260	
10/13/94	7F7D286645	226	88	0	94-A-261	
10/13/94	IF7D2C4F38	212	62	0	94-A-262	
10/13/94	7F7D286F1D	193	56	0	94-A-263	
10/13/94	7F780A6C04	215	72	0	94-A-264	
10/13/94	7F7D2C2E4C	192	50	0	94-A-265	
10/13/94	7F7D3E244E	192	58	0	94-A-266	
10/13/94	7F7D3E3073	250	118	0	94-A-267	
10/14/94	7F78101A42	203	66	0	94-A-268	
10/14/94	7T73080117	189	48	0	94-A-269	

Appendix B. Continued.

Date	PIT-tag number	Length	Weight	Mark	Scale sample number_	Comments
10/14/94	7F7D3E2437	187	47	0	94-A-270	
10/14/94	7F7D2B1F06	197	55	0	94-A-271	
10/15/94	7F7D2A7328	224	77	0	94-A-272	Body scratches
10/15/94	7F7D3E1761	200	66	0	94-A-273	Body scratches
10/15/94	7F7D3E2A59	192	56	0	94-A-274	Body scratches
10/15/94	7F7D2B087C	218	75	0	94-A-275	
10/15/94	7F7D370D6F	280	155	0	94-A-276	Chewed caudal area
10/15/94	7F7B115451	219	75	0	94-A-277	
10/15/94	7F7D2B6E21	236	105	0	94-A-278	
10/15/94	7F7B100812	213	63	0	94-A-279	Body scratches
10/15/94	7F7D1E7206	218	67	0	94-A-280	
10/15/94	7F7D2B1E3E	202	53	0	94-A-281	
10/15/94	7F7D2B0A41	425	645	ADIB	0	
10/15/94	7F7D3E1425	455	680	AD	0	
10/15/94	7F7D355C2A	442	620	AD	0	
10/19/94	7F7B0A6C79	185	52	0	94-A-282	
10/19/94	7F7D347A61	183	40	0	94-A-283	
10/21/94	7F7D3F4914	199	56	0	94-A-284	
10/21/94	7F7D1B5E15	196	60	0	94-A-285	
10/21/94	7F7D487516	161	30	0	94-A-286	
10/21/94	7P7809242C	198	62	0	94-A-287	
10/21/94	7F7D370700	200	56	0	94-A-288	
10/21/94	7F7B0E4F47	245	110	0	94-A-289	
10/21/94	7F7D2B6374	214	60	0	94-A-290	
10/21/94	7F7B100E60	200	62	0	94-A-291	
10/21/94	7F78100253	180	44	0	94-A-292	
10/21/94	7P78086F1D	184	48	0	94-A-293	
10/21/94	7F7B0E3D70	180	46	0	94-A-294	
10/21/94	7F7D370821	420	545	0	94-A-295	
10/21/94	7F7D2B6921	370	370	0	.94-A-296	Bite marks (1.5 cm)
10/21/94	7F7D284E61	190	58	0	94-A-297	
10/24/94	7F78102D1B	212	57	0	94-A-299	
10/24/94	7F780F4970	210	56	0	94-A-300	
10/24/94	7F7B067C22	172	22	0	94-A-301	
10/24/94	7F7B0F0631	156	12	0	94-A-302	
10/24/94	7F7D3E3270	183	30	0	94-A-303	
10/24/94	7F7D3A3800	180	22	0	94-A-304	
10/24/94	7F7D39044E	170	38	0	94-A-305	
10/24/94	7F7D383E2D	176	46	0	94-A-306	
10/26/94	7F7D487766	210	72	0	94-A-307	
10/26/94	7F7D1E7926	246	124	0	94-A-308	
10/27/94	7F7B0F233E	285	170	0	94-A-309	
10/27/94	7F7D2B6714	203	62	0	94-A-310	
10/27/94	7F7B0F6C70	217	76	0	94-A-311	
10/27/94	7F7D366066	197	55	0	94-A-312	
10/27/94	7F7D1B6223	226	82	0	94-A-313	

Appendix B. Continued.

Date	PIT-tag number	Length	Weight	Mark	Scale sample number	Comments
10/27/94	7F7D366528	22	82	0	94-A-314	
10/27/94	7F780E6703	19	66	0	94-A-315	
10/27/94	7F7D452D41	19	53	0	94-A-316	.-
10/27/94	7F7D2B7819	18	50	0	94-A-317	
10/27/94	7F7D3E3419	22	88	0	94-A-318	
10/27/94	7F7B0F3836	20	72	0	94-A-319	
10/27/94	7F7D1D6E5D	19	58	0	94-A-321	
10/27/94	7F780F3836	20	70	0	94-A-320	
10/27/94	7F7D2B0237	23	100	0	94-A-322	
10/27/94	7F7D2B7C23	20	70	0	94-A-323	
10/27/94	7F73023514	29	200	0	94-A-324	
10/27/94	7F7D7F674D	23	102	0	94-A-325	
10/27/94	7F7D3E100E	20	62	0	94-A-326	
10/27/94	7F7D1E7144	26	164	0	94-A-327	
10/27/94	7F7D280508	21	76	0	94-A-328	
10/27/94	7F7D3A3421	23	94	0	94-A-329	
10/27/94	7F7D367527	20	62	0	94-A-330	
10/27/94	7F7D2B6956	20	64	0	94-A-331	
10/27/94	7F7D7F5F30	19	56	0	94-A-332	
10/27/94	7F7D3A4865	19	52	0	94-A-333	
10/27/94	7F73085009	21	68	0	94-A-334	
10/27/94	7F7D2C2F35	21	70	0	94-A-335	
10/27/94	7F7D3E1614	18	52	0	94-A-336	
10/27/94	7F7D2CIA49	18	40	0	94-A-337	
10/27/94	7F7D2B150D	20	70	0	94-A-238	
10/27/94	7F7D3F5D52	21	78	0	94-A-339	
10/27/94	7F7D312440	15	25	0	94-A-340	
10/27/94	7F7D7F585E	38	390	0	94-A-341	
10/28/94	7F73084138	17	44	0	94-A-342	
10/28/94	7F7B086E61	'18	46	0	94-A-343	
10/28/94	7F7B0E541C	34	345	0	'94-A-344	
10/28/94	7F7D446425	22	80	0	94-A-345	
10/28/94	7F7D281812	19	62	0	94-A-346	
10/28/94	7F7D1B3913	20	64	0	94-A-347	
10/28/94	7F7B0F4571	19	56	0	94-A-348	
10/28/94	7F7D451863	32	260	0	94-A-349	
10/28/94	7F7D2B6C63	21	74	0	94-A-350	
10/28/94	7F7D3A2A33	18	46	0	94-A-351	
10/28/94	7F7D2B2B1D	21	70	0	94-A-352	
10/28/94	7F7B0A7611	22	88	0	94-A-353	
10/28/94	7F7D452008	47	740	AD	0	
10/28/94	777D2A7965	18	60	0	94-A-354	
10/28/94	7F7D7F5F2E	25	130	0	94-A-355	
10/28/94	7F7E6A4939	28	185	0	94-A-356	
10/28/94	7F7D3F7021	19	56	0	94-A-357	
10/28/94	7F7D3F4779	20	70	0	94-A-358	

Appendix B. Continued.

Date	PIT-tag number	Length	Weight	Mark	Scale sample number	Comments
10/28/94	7F7D38427C	251	120	0	94-A-359	
10/28/94	7F7D445C6C	225	99	0	94-A-360	
10/28/94	7F7D281405	200	59	0	94-A-361	
10/28/94	7F78085A04	191	50	0	94-A-362	
10/28/94	7P7D3F3C3C	222	82	0	94-A-363	
10/28/94	7F7D28180A	197	56	0	94-A-364	
10/28/94	7F7B0E6975	182	42	0	94-A-365	
10/28/94	7F7D3F305E	345	305	0	94-A-366	
10/28/94	7F7D2C2750	221	66	0	94-A-367	
10/28/94	7F7D2B166A	340	288	0	94-A-368	
10/28/94	7F7D4B615C	202	58	0	94-A-369	
10/28/94	7F7D2C335D	237	100	0	94-A-370	
10/28/94	7F780F3D5D	188	50	0	94-A-371	
10/28/94	7F7D3F372D	190	54	0	94-A-372	
10/28/94	7F7E686945	207	64	0	94-A-373	
10/28/94	7F7D383F53	221	86	0	94-A-374	
10/28/94	7F7D446916	203	64	0	94-A-375	
10/28/94	7F7D31112D	207	66	0	94-A-376	
10/28/94	7F7BOF511A	217	74	0	94-A-377	
10/28/94	7F7D354B49	178	40	0	94-A-378	
10/28/94	7F7D3A4221	206	62	0	94-A-379	
10/28/94	7F7D3E3708	203	64	0	94-A-380	
10/28/94	7F7D7F7449	224	92	0	94-A-381	
10/28/94	7F7D356829	239	102	0	94-A-382	
10/28/94	7F7D367D64	227	80	0	94-A-383	
10/28/94	7F7D390539	236	96	0	94-A-384	
10/28/94	7F78034849	183	45	0	94-A-385	
10/28/94	7F7D371113	208	66	0	94-A-386	
10/28/94	7F7D2C1737	205	62	0	94-A-387	
10/28/94	7F7D3F4C16	300	205	0	94-A-388	
10/28/94	7F7D36784C	198	54	0	'94-A 389	
10/28/94	7F7D2O0031	216	70	0	94-A-390	.
10/28/94	7F7D354779	312	225	0	94-A-391	
10/28/94	7F7D366340	208	66	0	94-A-392	
10/28/94	7F7D366249	208	62	0	94-A-393	
10/28/94	7F7D370D67	206	58	0	94-A-394	
10/28/94	7F7D35434B	246	104	0	94-A-395	
10/28/94	7F730E6955	219	78	0	94-A-396	
10/28/94	7F7D367F40	210	74	0	94-A-397	
10/28/94	7F7D286650	268	150	0	94-A-398	
10/28/94	7F7B0F6F65	184	44	0	94-A-399	
10/28/94	7F7D48795E	196	54	0	94-A-400	
10/28/94	7F7D2B7839	250	102	0	94-A-401	
10/28/94	7F7D4B7620	187	44	0	94-A-402	
10/28/94	7F7D36376E	277	160	0	94-A-403	
10/28/94	7F7D38452C	365	350	AD	94-A-404	

Appendix B. Continued.

Date	PIT-tag number	Length	Weight	Mark	Scale sample number	Comments
10/28/94	7F7D384016	223	76	0	94-A-405	
10/28/94	7F7B076352	231	86	0	94-A-406	
10/28/94	7F7D370156	192	49	0	94-A-407	
10/28/94	7F7D2C3348	186	48	0	94-A-408	
10/28/94	7F7D366903	185	44	0	94-A-409	
10/28/94	7F78086743	242	112	0	94-A-410	.
10/28/94	7F7D49025F	226	80	0	94-A-411	
10/28/94	7F7D1A4B74	265	133	0	94-A-412	
10/28/94	7F7D71'6E7F	204	60	0	94-A-413	
10/28/94	7F7D2B506E	200	57	0	94-A-414	
10/28/94	7F702C4B3D	191	50	0	94-A-415	

ANNUAL PERFORMANCE REPORT

State of: Idaho

Grant No.: F-73-R-17. Fishery Research

Project No.: 6

Title: Bull Trout Investigations

Subproject No.: 2. Bull Trout Aging Studies

Contract Period: July 1. 1992 to June 30. 1993

ABSTRACT

Very few estimates of bull trout *Sa/ve/inus confluentus* age-growth are available for Idaho waters. Estimates have typically been based on scales which have been shown to be of questionable reliability for species of char. I compared age estimates from scales and otoliths for fluvial bull trout for Rapid River, Middle Fork Salmon River, Upper Salmon River, Crooked River, and South Fork Boise River. Age estimates from scales and surface aged otoliths agreed in 74% of the 109 paired samples from Rapid River, similar to 1993 results. In the Middle Fork Salmon River, however, only 18% of the paired scale and surface aged otolith samples were in agreement. Age comparisons between cross sectioned otoliths versus scales and surface aged otoliths also provided mixed results. In Rapid River, where scales generally agreed with surface otolith age estimates, cross section otolith ages indicated 1 to 4 years older for individual fish. These differences were substantial enough to confound any attempt to estimate mortality rates for this stock using age data derived from scales. In Middle Fork Salmon River, cross section and surface otolith ages agreed more often, but were generally older than scale estimates.

Where scale and otolith age estimates disagreed, scales typically produced ages 1 year lower. I believe this error can partially result from our failure to detect the first annulus on a portion of very small bull trout which have only laid down 2 to 3 circuli going into the first winter. Additional aging errors appear to occur at older ages in larger fish.

Agreement between readers also provided mixed results between stocks and structures. Agreement between readers was 69% for scales and 81 % for otoliths for Rapid River bull trout. Agreement between readers was only 40% for scales and 33% for otoliths in Middle Fork Salmon River samples. Agreement for scale aging between readers for Upper Salmon River, Crooked River, and South Fork Boise River was 61%, 76%, and 60%, respectively.

Based on our results from 1993 and 1994, we recommend the use of otoliths for aging as the basis of future management decisions for fluvial bull trout in Idaho. Since age estimates from the three methods varied widely in some waters, we have no way of knowing which is correct. Therefore, use of the structure generally producing the slowest growth estimates (sectioned otoliths) will provide the most conservative management.

Because of mortality from the collection of otoliths, we recognize collection of otoliths will be limited due to the depressed status in most populations. Therefore, scales will likely continue to be the primary aging method for bull trout in the northwest. Managers must remember bull trout scales may provide substantial underestimates of age. An underestimate of age results in overestimates of population mortality rates, possibly resulting in unsound harvest management decisions. Estimates from scales may become more suspect if the no-kill regulations initiated in Idaho January 1, 1994 result in survival of individual bull trout to older ages.

Based on my results and the literature, I conclude present bull trout aging work in Idaho and elsewhere requires validation through mark-recapture evaluations using known age fish. Although I suspect scales underage fluvial bull trout, it is possible that checks on the otoliths account for the disparity. Until age validation of various structures is conducted, any estimates of bull trout age, growth, and associated mortality rates should be viewed with caution.

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INTRODUCTION

Accurate age estimates are necessary to properly evaluate a fish stock (Ricker 1973; Beamish and McFarlane 1983). If age estimates are inaccurate, serious errors can result in management of the stock through incorrect assessments of longevity and mortality rates. Depending on the bias, such errors can result in excessively liberal or overly restrictive harvest regulations for a fish population (Leaman and Nagtegaal 1987).

Limited age data exists for fluvial bull trout *Salvelinus confluentus* in Idaho. Past studies have generally rElled on scale aging (Pratt 1985; Irving 1986; Thurow 1987; Corsi and Elle 1989). However, bull trout scales are extremely difficult to age, especially for older fish. Thurow (1987) ceased attempts at aging bull trout greater than five years of age with scale samples from South Fork Salmon River fish.

In recent years, scales have been shown to be unreliable for aging several species of char, including lake trout S. *namaycush* and Artic char S. *arcticus* (Baker and Timmons 1988; Beamish and McFarlane 1983 and 1987; Barber and McFarlane 1987; Power 1978). For aging char, the concern in using scales usually lies in assigning ages to older fish; they are often underestimated (Barber and McFarlane 1987; Power 1978). Schill (1991) reported consistently older age estimates using otoliths compared to scales in a limited sample of fluvial Idaho bull trout. However, Schill (1992) reported comparable age determinations for bull trout from an adfluvial stock (Lake Pend Oreille) using otoliths, scales, and fin rays.

I demonstrated similar age results from scales and otoliths up to seven years old for two fluvial bull trout populations in Idaho (Elle et al. 1994). However, back-calculations of length-at-age from scales from these populations were above those from other studies in the northwest, and I suspected error in assigning annuli. Otolith ages were based on surface aging of whole otoliths, not cross-sections. In char and other species, cross sectioned otoliths can yield older age estimates compared to surface aging, especially for older individuals (Chilton and Beamish 1982, Barber and McFarlane 1987).

Lack of validation for any aging estimates raise questions about the reliability of age determinations (Beamish and McFarlane 1983). A limited degree of confidence is attained, however, by comparing age determinations of several structures for individual fish (Beamish and

OBJECTIVES

Research Goal: To provide sufficient life history data to maintain and restore bull trout for trophy fishing opportunities.

1. To determine the best structures for aging stocks of fluvial bull trout in Idaho.

2. To estimate growth rates of bull trout stocks from various Idaho waters.

METHODS

Sampling

Rapid River

I collected scales from bull trout trapped during spring upstream migration during 1993 and 1994 and fall downstream migration during 1993 and 1994 in Rapid River. Samples from additional small fish were collected during fall 1993 and 1994 using electrofishing methods in two headwater spawning streams; Lake Fork and Granite Fork. A total of 247 useable scale samples were analyzed for aging and back-calculations of growth. I collected otoliths from 124 of the same fish. Otolith samples were collected from trapping mortalities and from deliberate sacrifices for the aging study. One hundred and nine useable scale and otolith samples existed for paired comparisons. Fish in this sample ranged from 44 mm to 615 mm total length.

Middle Fork Salmon River

We sampled bull trout from the Middle Fork Salmon River during spring 1993 and 1994 using hook-and-line sampling. A total of 63 scale and 18 otolith samples were collected for aging. Seventeen samples were useable for paired comparisons. Fish ranged in length from 110 mm to 550 mm total length.

Crooked River Drainage

Crooked River is a tributary to the South Fork Clearwater River. Scale samples were collected from bull trout at Crooked River upstream and downstream migration weirs during 1992 and 1993. A sample of smaller fish were collected in Mores Creek, a headwater tributary, using electrofishing methods during 1993. A total of 107 useable scale samples from fish ranging in length from 81 mm to 500 mm total length were used in back-calculations. No otolith samples were collected.

Upper Salmon River Drainage

Scale samples were collected at the Sawtooth Hatchery upstream weir during spring 1992, 1993, and 1994. A sample of smaller bull trout were sampled in Fourth of July Creek, upstream from the Sawtooth Hatchery, during 1992. A total sample of 62 readable scales were used for back-calculations. Fish size ranged from 112 mm to 670 mm total length.

South Fork Boise River

Regional personnel collected scale samples from 15 bull trout during fall 1993 and 1994 population estimates via electrofishing methods. Only larger bull trout (243 mm to 514 mm) were captured. No tributary sampling was available for the South Fork Boise River.

East Fork Salmon River

Structures were collected in 1991 and 1993 from the East Fork Salmon River. Scales were collected from adult bull trout at the upstream anadromous hatchery trap. Shoshone-Bannock tribal biologists collected scale samples from juvenile bull trout at a downstream screw trap. Additional small bull trout were collected from a tributary to the East Fork, West Pass Creek. A total sample of 144 scale and 15 otolith samples were suitable for aging. Fish ranged from 134 mm to 721 mm total length.

Structure Preparation and Aainq

Scale and otolith sampling and structure preparation are described in detail in Elle et al. (1994). Whole otoliths were surface aged using a dissecting microscope with reflected or transmitted light. Otolith cross sections were prepared as described by Chilton and Beamish (1982). For cross sectioned otoliths, I mounted the sagittal otoliths in epoxy (Dextor Corporation: EPK 0151 resin, EPK 0141 hardener) in individually numbered rubber molds (Pelco 105). After drying 24 hours, a Bromwill saw was used to cut cross sections (approximately 0.6 mm thick). The cross sections were mounted on slides and subsequently "roasted" using a Corning hot plate (model 300) at temperature setting 4 (approximately 650°F) until the cross sectioned otolith turned brown. Vegetable oil was used to enhance the hyaline rings. The cross sections were read with a compound microscope at 40x power. Aging criteria described in Chilton and Beamish (1982) were used for scale and otolith analysis. I used Texas Instruments Hipad in conjunction with DISBCAL 89 program (Missouri Department of Conservation 1989) to digitize scale focus, annuli, and margin measurements for scale back-calculations. An eyepiece micrometer in a binocular microscope was used to derive the same measurements for otoliths. Structures were aged independently by two readers and age was recorded. The readers had no knowledge of fish lengths during the reading of any structure.

After all structures were aged, estimates resulting in disagreement between readers were jointly read to reconcile a final age (Lorson and Marcinko 1990).

Size at Scale Formation

I sampled young-of-the-year and age 1 + and 2+ bull trout in Lake Fork and Granite Fork, Rapid River headwater tributaries, to determine if all bull trout form scales during their first year. If bull trout do not form scales prior to the first winter, aging estimates will be biased low. A subjective determination was made regarding the likelihood of scale formation based on fish size at capture and growing season remaining prior to winter annulus formation.

Structure Comparisons

I graphically compared age estimates from paired scale and otolith samples from Rapid River and Middle Fork Salmon River. Reconciled ages were used for comparison of structure ages. A plot of scale age to otolith age for individual fish should have a slope of 1.00 if there is 100% agreement between structures (Lorson and Marcinko 1990; Barber and McFarlane 1987). Estimates of scale and otolith age were plotted and regression statistics calculated. I tested a null hypothesis of no difference in age estimates between structures by statistically comparing the regression slope to 1.00 (Zar 1984). I made a further comparison of scale and surface otolith age estimates to the cross sectioned otolith age estimate for selected larger fish from the fluvial populations in Idaho. Data for these comparisons are presented by individual fish for evaluation of the three aging methods.

I determined percent agreement between readers for individual structures and between structures. Percent agreement was calculated as the proportion of times age estimates yielded 1 year older in 1994 versus 1993.

Back-calculated Length-at-age

We calculated length-at-age estimates using the Dahl-Lea method for otolith analysis and the Fraser-Lee method for scale analysis.

Dahl-Lea method (Dahl 1910). This method was used to back-calculate ages based on direct proportions using the following formula.

$$L_i = L_c \frac{O_i}{O_c} \qquad (1)$$

Where:

L_i = length of the fish at age i,
L_c = length of the fish at capture,
O_i = otolith measurement to annulus i, and
O_c = otolith measurement to margin at capture.

Fraser-Lee (Fraser 1916; Lee 1920). This is a direct proportion method using the following equation for back-calculation.

$$L_1 = \frac{S_i}{S_c}(L_c - a) + a \qquad \textbf{(2)}$$

Where:

a = constant derived as the y-intercept from the body-scale regression.
S_i = scale measurement to annulus i, and
S_c=scale measurement to margin at capture.

For Rapid River bull trout the constant equalled -27.6. For Crooked River drainage the constant equalled -27.0. Insufficient numbers of juvenile fish were available to derive a body scale constant in samples from Upper Salmon River drainage, Middle Fork Salmon River, East Fork Salmon River, and the South Fork Boise River. I used the constant from Rapid River for back-calculation of ages in these waters.

Age Validation

I attempted to validate scales as an aging structure in Rapid River by comparing scale samples from bull trout sampled initially in fall 1993 and subsequently recaptured in 1994. During September and October 1993, downstream emigrating bull trout were captured at a weir in lower Rapid River. Fish were tagged using Passive Integrated Transponder (PIT) or floy tags. Scale samples were collected from the left side of the body from the majority of these fish. During the spring of 1994, all upstream migrating bull trout captured at an upstream fish trap were examined for PIT or floy tags. Workers collected a second scale sample for any tagged fish. The spring scale sample was taken from the right side of the body. A total of 14 fish had readable scale samples from both 1993 and 1994.

Theoretically, all bull trout should form an annulus during the winter/spring period. I assumed annulus formation occurred prior to upstream migration during May and June. Based on the assumption of annulus formation, estimated scale ages for all bull trout should be one year greater in 1994 compared to 1993.

RESULTS

Size at Scale Formation

I sampled in two Rapid River headwater reaches September 12, and collected scales from 28 bull trout ranging from 43 mm to 165 mm total length. All bull trout larger than 50 mm had formed scales. Out of 10 fish sampled which I believed were age 0, two (43 mm and 50 mm) did not have scales formed in the area below the dorsal fin. A fish 47 mm long did have scales. Based on the remaining growing season of September through mid-November, I believe bull trout in Rapid River grow larger than 50 mm and most likely form scales prior to the end of the growing season. Due to the short growing season remaining, fish which have not formed scales as of early September probably only form 1 to 3 circuli prior to formation of the annulus.

For our samples from early September, age 0 bull trout ranged from 43 mm to 62 mm. This size roughly appears to be the break between age 0 and age 1 bull trout for this time of the year. Age 1 fish ranged from 92 mm to 106 mm with one scale age 1 for a 145 mm fish. Age 2 fish ranged from 137 mm to 165 mm within our sample. A single fish 84 mm in length was aged as age 0 by scales and age 1 by otoliths.

Structure Comparisons

For Rapid River, age estimates from scales were in agreement 74% of the time compared to surface aged otoliths (Table 1). When scale and otolith ages disagreed, scales were within one year and generally provided estimates one year younger. The regression slope of otolith age versus scale age of 1.08 was not significantly different from the hypothesized slope of 1.00 (P 20.05) (Figure 1).

For Middle Fork Salmon River, however, only 18% of the scale and surface otolith ages were in agreement. The majority of assigned ages differed by one year (54%) and 27% of the structure ages were off by two years (Table 2). Scale ages consistently provided lower ages compared to otolith ages when the structures were in disagreement (Figure 2). Despite limited sample size, the regression slope of this relationship was significantly different ($P < 0.05$) from that hypothesized (1.24 versus 1.00).

Estimated ages from otolith cross sections compared to surface otolith ages provided different results among drainages (Table 2). In the mainstem and Middle Fork Salmon rivers, cross section ages agreed with surface ages for most sizes of bull trout including one fish 700

Table 1. Percent agreement between two readers and two aging structures for bull trout in Middle Fork Salmon River, Rapid River, East Fork Salmon River, Upper Salmon River, South Fork Boise River, and Crooked River.

			Percent agreement[a]		
Water body	Structure	Number	Complete	Within one year	Greater than one year
Middle Fork Salmon River	Scales	30	40		
	Whole otoliths	12	33		
	Scales vs otoliths	11	18	54	27
Rapid River	Scales	247	69		
	Whole otoliths	124	81		
	Scales vs otoliths	109	74	26	0
East Fork Salmon River[b]	Scales	142	62		
	Whole otoliths	15	74		
	Scales vs otoliths	14	57	43	0
Upper Salmon River	Scales	62	61		
South Fork Boise River	Scales	15	60		
Crooked River (Clearwater River)	Scales	107	76		

[a] For individual structures, these values apply to agreement between readers.
[b] Elle et al. 1994

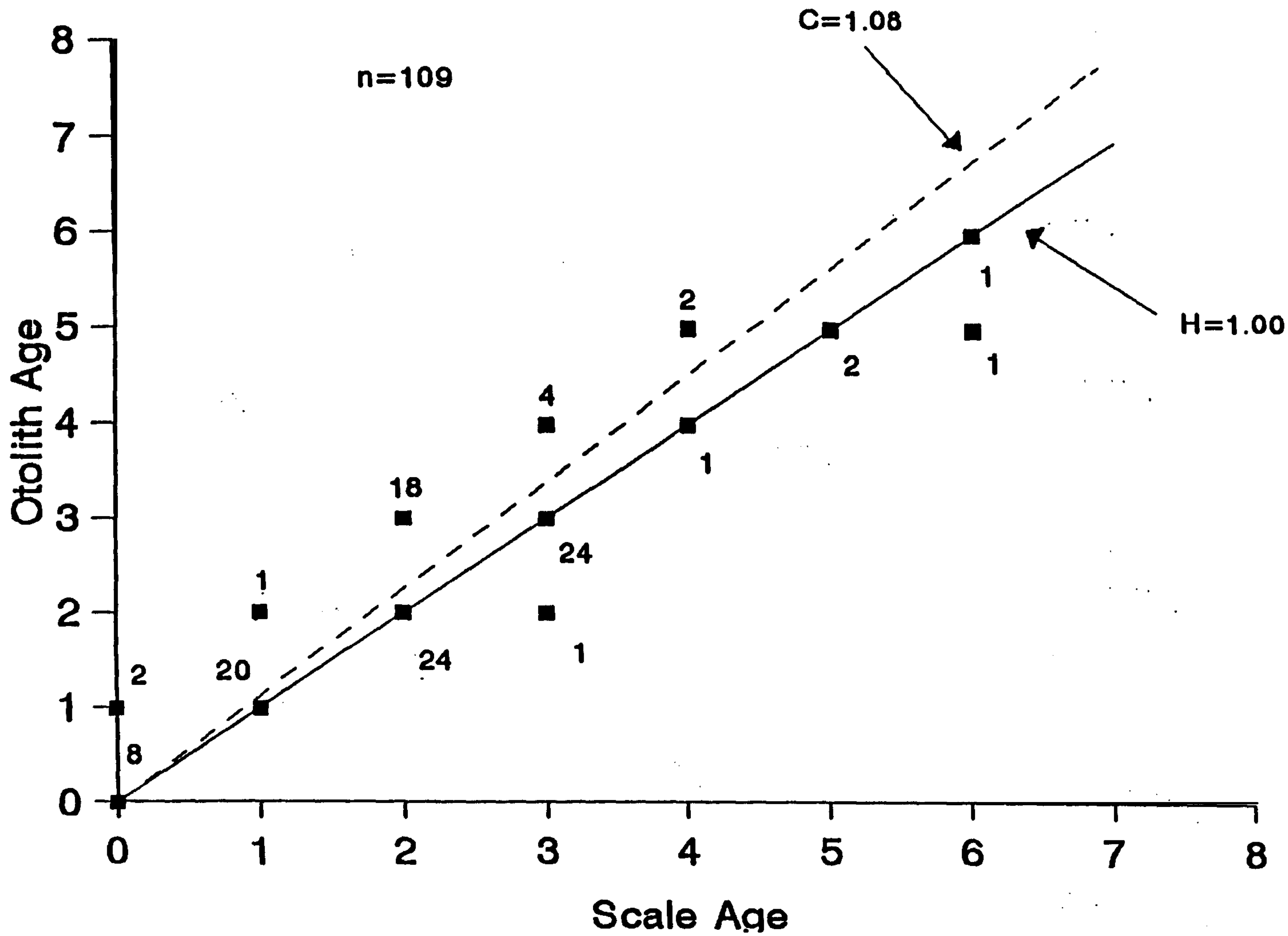

Figure 1. Scale age compared to otolith age of bull trout from Rapid River, 1994. (H = Hypothesized slope = 1.00, C = Calculated slope = 1.08).

Table 2. Comparison of age analysis from scales, surface otoliths, and cross-sectioned otoliths for bull trout from fluvial populations in Idaho.

			Estimated age by structure		
			Scale	Otoliths	
Water body	Length (mm)			Surface age	Cross section
Mainstem Salmon River	457	U	--	8	8
	457	U	--	7	7
	508	U	--	6	8
	559	U	--	7	7
	700	U	10	10	11
Middle Fork Salmon River	290	F (I)	4	3	4
	291	U	4	6	5
	340	F (1)	6	6	6
	380	F (I)	5	8	7
	435	F (1)	6	6	6
	450	M (M)	5	7	6
	460	F (M)	6	8	8
	480	F (M)	5	6	8
	525	M (M)	6	7	7
	550	M (M)	4	6	9
East Fork Salmon River	718	M (M)	7	6	10
Rapid River	359	F (M)	3	4	8
	373	F (M)	5	5	8
	413	F(M)	4	5	8
	454	F (-)	6	6	9
	498	U	--	6	7
	580	M (M)	6	6	9
	615	U	--	5	8
Crooked River (Clearwater River drainage)	489	M (M)	6	8	9
South Fork Boise River	391	U	5	5	8

• F= female, M = male, U = unknown, (I) = immature, (M) = mature, (-) = unknown.

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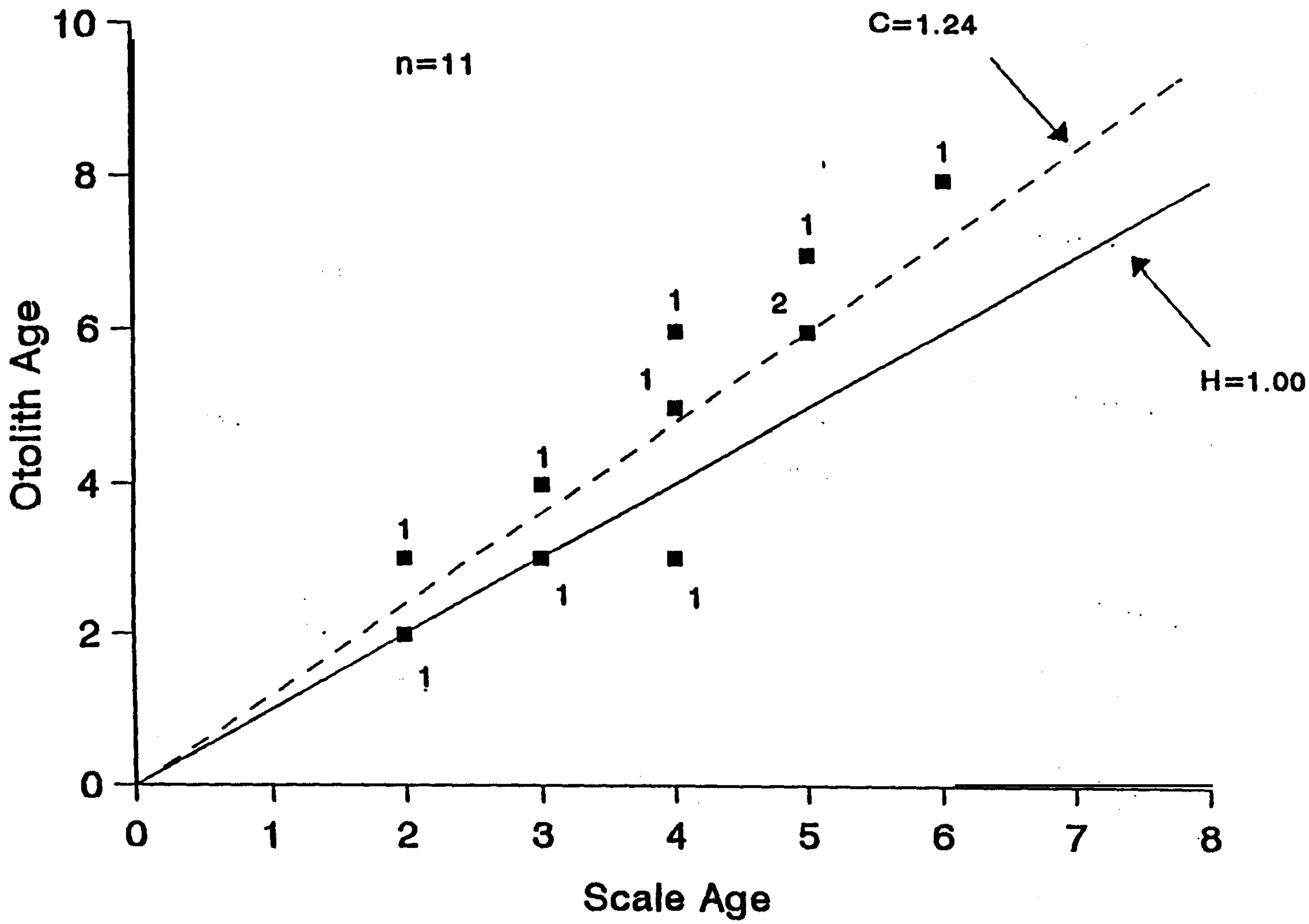

Figure 2. Scale age compared to otolith age of bull trout from Middle Fork Salmon River, 1994. (H = Hypothesized Slope = 1.00, C = Calculated Sloope = 1.24).

Table 3. Number of circulii to first annulus for bull trout collected in Rapid River during fall 1994. Fish length and agreement of age by scale and otolith analysis provided for comparison.

	Age		Circulii count to first annulus	
Length Imm)	Otolith	Scale	Age agreement	Aae disagreement
162	2	2	14	
162	2	2	7	
165	2	2	9	
166	2	2	8	
173	2	2	10	
174	2	2	.12	
174	2	- 2	9	
174	.2	2	11	
177	.2	2	11	
180	2	2	11	
184	2	2	8	
186	2	2	7	
187	2	2	10	
193	2	2	9	
193	2	2	9	
195	2	2	9	
195	2	2	13	
200	2	2	9	
202	3	2		10
202	3	2		6
203	2	2	13	
207	2	2	13	
209	3	2		9
213	3	2		12
215	2	2	10	
215	3	2		7
217	3	2		10
223	3	3	8	
223	3	3	9	
228	3	2		8
228	3	2		8
230	3	2		13
240	3	2		8
241	4	3		11
244	3	3	7	
246	3	2		13
250	3	3	9	
252	3	3	12	
256	3	3	7	
257	3	3	7	
258	3	2		10
262	3	3	6	
270	3	2		10
272	3	3	9	
362	4	4	15	
Number			31	14
Mean			9.71	9.64
Standard deviation			2.298	2.134

between these values (t-test $P<0.05$). Based on scale circuli counts, we cannot determine when an annulus may be missed by aging technicians.

Back-calculated Length-at-age

Scales and otoliths provided similar back-calculations for age 1 and age 2 for Rapid River bull trout (Table 4). Otoliths indicated smaller sizes at annulus for age 3 to 5 year old fish compared to scales. Otoliths estimated higher fish length at annulus 6 compared to scales.

As noted previously, scale samples on all waters except Rapid and Crooked rivers were too sparce for estimation of body-scale constants. The regression on these waters typically produced poor r^2 values. I back-calculated length-at-age using Fraser-Lee with the Rapid River scale constant (c=-27.6) in these waters. Overall, estimates were calculated for Rapid River, Middle Fork Salmon River, East Fork Salmon River, upper Salmon River, Crooked River of the Clearwater Drainage, and South Fork Boise River. Crooked River had the slowest growing population of the study streams (Table 5). The South Fork Boise River had the highest growth rates. The small sample size and lack of small fish sampled in the Boise River probably biases the results. Populations from the Middle Fork Salmon, East Fork Salmon, and upper Salmon rivers had similar length-at-annulus through age 3. The growth increased at age 4 for the East Fork Salmon River.

Age Validation

Comparison of scales collected from the same fish during 1993 and 1994 for 14 Rapid River bull trout provided discouraging results. If scale aging accurately estimates bull trout age, I would expect the 1994 samples to indicate 1 year older compared to the 1993 samples. Only 28% (4 fish) of the 1994 scale samples were aged as one year older compared to the 1993 age (Table 6). Thirty-six percent of the sample indicated plus 2 years in age and 36% indicate the same age in 1994 versus 1993 (Appendix A). Although the sample size is small, these data indicate scales do not provide accurate ages for bull trout larger than 278 mm.

DISCUSSION

Scales have long been used as a tool to age fishes. The collection and analysis of scales is generally less time consuming and does not result in mortality to fish. During the 1970s and 1980s, however, studies have shown age estimates from scale analysis have resulted in under-estimates of the true age of some fish (Beamish and McFarlane 1987). Age estimates from otoliths in studies reviewed by Beamish and McFarlane indicated the presence of 21-year-old to 60-year-old fish for various species compared to scale ages of 5 years to 20 years. In particular, aging studies of the char family indicate otoliths provide superior age determinations, especially for older fish (Baker and Timmons 1988; Beamish and McFarlane 1983 and 1987; Barber and McFarlane 1987; Power 1978; Kozei and Hubert 1987).

Researchers continue to debate the use of scales versus otoliths for bull trout age analysis. Elle et al. (1994) concluded scales provided a comparable estimate to surface otolith

Table 4. Comparison of back-calculated length-at-age for bull trout from Rapid River. Ages determined based on scale and otolith samples collected during 1993 and 1994. .Scale ages based on Frasier-Lee back-calculation using constant = -27.6. Otolith ages based on Dahl-Lea method of back-calculation.

Age		Calculated mean total length (mm) at annulus					
Group	N	1	2	3	4	5	6
				Scales			
29		60					
II	88	70	143				
III	82	64	141	221			
IV	24	80	160	249	328		
V	10	69	138	217	302	402	
VI	3	58	129	204	277	366	459
Grand mean		68	144	226	317	394	459
Number of fish		236	207	119	37	13	3
Incremental growth		68	76	82	91	77	65
				Otoliths			
23		75					
II	27	83	140				
III	41	86	150	199			
IV	6	91	165	214	260		
V	5	101	153	219	273	336	
VI	4	90	179	260	320	412	495
Grand mean		84	149	207	281	370	495
Number of fish		106	83	56	15	9	4
Incremental growth		84	65	58	74	89	125

Table 5. Back-calculated length-at-age of fluvial and adfluvial bull trout from selected waters.

Water body		Calculated mean total length (mm) at annulus							
		1	2	3	4	5	6	7	8
<u>Fluvial Salmon</u>									
Rapid River	This study	68	144	226	317	394	459		
Middle Fork Salmon River	This study	72	144	227	306	366	422		
East Fork Salmon River	This study	75	150	237	349	431	526	647	
Upper Salmon River	This study	72	141	215	285	356	435	476	500
Crooked River	This study	66	119	189	286	371	424		
South Fork Boise River	This study	81	168	248	341	398	439		
South Fork Salmon River	Thurow, 1987	68	110	154	217	284			
Sawmill Creek	Corsi and Elle, 1989	99	155	240	314				
Upper Flathead tributaries	Shepard et al., 1982	72	108	140					
Middle Fork Flathead River	Shepart et al., 1982	48	97	174	286	389	484	575	
Toboggan Creek	Leathe and Graham, 1982	48	99	165	229				
Wigwam River	Leathe and Graham, 1982	64	114	176	385	476	557	668	
<u>Adfluvial</u>									
Flathead Lake									
1963-1981	Shepart et al., 1982	68	130	204	292	384	472	567	
1955	Shepart et al., 1982	76	150	234	335	457	566	691	
1963	Shepart et al., 1982	71	140	208	323	452	594	724	
Hungry Horse Reservoir									
1953 and 1972	Shepart et al., 1982	72	144	225	324	429	513	594	
Lake Kookanusa	Leathe and Graham, 1982	67	123	212	309	390	482	518	
Priest Lake	Shepart et al., 1982	71	114	183	310	424	516	605	
Upper Priest Lake	Shepart et al., 1982	66	102	155	239	358	462	546	
Lake Pend Oreille	Shepart et al., 1982	91	164	272	403	497	578		
Metolius River	Pratt, 1991	72	130	196	290	433	633	821	

Table 6. Comparison of estimated age for Rapid River bull trout sampled during fall 1993 and spring 1994. Ages should theoretically indicate 1 year older during 1994 following over-winter annulus formation.

1993		1994		Age comparison		
Length (mm)	Age	Length (mm)	Age	+1 year	+2 years	No change
278	3	370	4	X		
330	3	427	5		X	
337	4	405	5	X		
355	4	396	4			X
360	4	415	4			X
375	4	424	5	X		
386	3	440	5		X	
390	3	529	5		X	
393	4	445	5	X		
418	3	489	5		X	
447	4	500	6		X	
456	5	518	5			X
465	5	498	5			X
476	5	540	5			X
Number				4	5	5
Percent				28%	36%	36%

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ages for Rapid River bull trout. Pratt (1991) and Shanye MacLellan (Nanaimo Fish Aging Lab, personal communication) believe scales and otoliths provide similar results for aging bull trout from two adfluvial populations (Lake Pend Oreille and Lake Billy Chinook). Heiser (1966) and Mackay et al. (1990) indicate otoliths are superior to scales for bull trout/Dolly Varden because scales tend to under-age older fish. Jim Stelfox (Alberta Fish and Wildlife, personal communication) believes scales are inadequate for aging bull trout over age 4.

Past studies have documented that for many fish species, otolith cross section age estimates often provide significantly higher age estimates for older individuals than whole otoliths (Macer 1968; Blacker 1974; Power 1978; Beamish 1979; Kristoffersen and Klemetsen 1991; Leaman and Nategaal 1987; Chilton and Beamish 1982; Barber and McFarlane 1987). Our age estimates provided mixed results in comparing cross section to surface otolith age estimates. In Rapid River, where scales generally agreed with surface otolith age estimates, cross sections provided age estimates 1 to 4 years older for individual fish. Cross section otolith sample provide much greater definition of the hyaline regions (slow growth zones) compared with surface aging. In Rapid River, the higher ages estimates from cross sectioned otoliths may be due to spawning or other growth checks which are not visible in the surface otolith readings. In Middle Fork Salmon River cross section and surface otolith ages agreed more often but were generally older than scale estimates.

For individual fish we noted a lack of continuity in our comparisons of structures. For a 700 mm fish from the main Salmon River, scale, surface, and cross section otolith ages were all in close agreement. But for a 715 mm fish from East Fork Salmon River, estimated ages were higher for cross section otolith compared to surface aged otoliths which were higher than scale age estimates. For bull trout, Stelfox (Alberta Fish and Wildlife, personal communication) believes surface otolith readings are only valid to ages 6 to 8, and Theisfeld (Oregon Department of Fish and Wildlife, personal communication) believes surface otolith ages are only accurate up to age 6. With the mixed results from our data comparing surface to cross section otolith readings, we believe at least a sample of otolith from fluvial bull trout should be cross sectioned to compare with surface reading.

Compared to other fluvial studies, my scale aging evaluations resulted in similar estimated length-at-annulus for age 1 bull trout but higher estimates for ages 2 and 3 (Table 5) (Appendix B). Back-calculations from my study streams are higher compared to studies of other fluvial populations in northwest states (Table 5). The South Fork Salmon River is probably the most comparable drainage to our streams. Thurow's (1987) estimated length-at-age calculations for bull trout for the South Fork Salmon River are more similar to other Idaho and Montana streams than to this data. Data from adfluvial populations are closer to my growth estimates for age 1 to age 3 fish.

The discrepancies could indicate that I may have missed an annuli on some fish. My results indicate scale age estimates for Rapid River bull trout are one year lower compared to surface otoliths 25% of the time. Estimates indicate only 18% agreement for Middle Fork Salmon River and 57% for the East Fork Salmon River (Elle et al. 1994) for comparisons of scales and surface aged otoliths. Pratt (1991) found a 25% disagreement between scale and surface otolith ages for adfluvial bull trout in the Metolius River system in Oregon. Readers need to keep in mind percent agreement between structures provides a measure of comparison of two or more structures. Percent agreement, however, only measures whether an age agrees between structures or readers. It does not measure the magnitude of difference in age between determinations or the number of age classes in the population (Laine and Momot 1991).

in general, scale and surface otolith ages were within one year of each other (Pratt 1991, Elle et al. 1994). However, sectioned otoliths provided age estimates of 4 or more years compared to scales in some populations. If my scale analysis underestimates the true age of older bull trout by multiple years, it would result in profound errors in management decisions.

Failure to form a scale in the first year by a portion of the bull trout population would affect our scale aging results. I reviewed size at scale formation for bull trout in Rapid River to try to determine if I missed recognition of the first annulus. Although studies have documented cutthroat trout failure to form a scale in the first year (Lentch and Griffith 1987, Mallet 1963), I found no evidence bull trout exhibit this phenomenon. I am not aware of any studies for bull trout documenting failure to form scales in the first year. Bull trout in Rapid River form scales around 50 mm in size, and I believe all fish in the drainage attain this size by the end of the growing season.

Small fish which form scales late in the fall will have low numbers of circuli prior to annulus formation. Chilton and Beamish (1982) suggest defining the first annulus of an aging structure is critical in fish stocks. Stelfox (Alberta Fish and Wildlife, personal communication) had difficulty correctly identifying the location of the first annulus on bull trout. Lack of recognition of a poorly defined annulus at age 1 on bull trout which only form 2 to 3 circuli prior to winter may account for scale estimates which are lower than otolith estimates. These errors would result in back-calculations for length-at-annulus which are overestimates of the size of fish at annulus, especially the younger age classes.

An indication that I missed the first annulus in a portion of our samples would be high circuli counts to the first annulus (Pratt, K.L. Pratt Consulting, personal communication). I reasoned where scale and otolith ages for the same fish disagreed, the number of circuli to the first annulus on scales would be higher compared to cases where ages agreed. I found no difference in the number of circuli between paired samples which agreed versus those that did not agree. For both samples, we had some high circuli counts, some as high as 13 circuli to annulus. Although such high counts could indicate a missing annulus, the fact that otoliths agreed with scale ages in some of the cases of high counts precluded the use of circuli counts to first annulus as a tool to reduce scale aging error.

I attempted to "validate" scale ages by sampling bull trout PIT-tagged in Rapid River during 1993 and recaptured in 1994. Results from this analysis were inconsistent. Bull trout sampled either did not lay down annuli consistently, or more likely, mis-aging the fish in either 1993 or 1994, or both, causes a large source of error. Although based on a small sample, the results call into question the advisability of using scales for aging bull trout, at least using our methods. As fish get older the discrepancy will likely increase (Kristoffersen and Klemetsen 1991; Kozei and Hubert 1987; Leaman and Nagtegaal 1987). If bull trout respond to the present Idaho no kill regulations by surviving to older ages, scale age estimates may provide less accurate estimates of bull trout in the future.

Given these results and discrepancies reported between scales and otoliths in this and other studies (Pratt 1991; Heiser 1966, Elle et al. 1994), a true validation of various aging structures is needed for fluvial Idaho bull trout. We PIT-tagged over 600 bull trout, primarily 2 to 3 year old juveniles emigrating from Rapid River during 1993 and 1994, to assess survival rates in the Salmon River. Continued monitoring of these marked fish in Rapid River will provide additional samples for age validation. Additionally, recaptures of marked fish will allow us to develop relationships of growth over time which will provide another tool to evaluate our growth estimates. Despite my reservations regarding scale analysis, observed growth for bull trout captured in Rapid River during fall 1993 and recaptured in summer 1994 do correspond reasonably well with growth estimates from scale back-calculations. Fish grew 50 mm to 100+ mm from age 3 to age 5 (Subproject 2), with larger growth observed in the smaller (<300 mm) fish.

Age validations studies should be an integral part of all age and growth evaluations for fish species with older aged individuals and char in particular (Beamish and McFarlane 1983 and 1987; Power 1978; Kristoffersen and Klemetsen 1991; Barber and McFarlane 1987). Without age validation, scales or otoliths could provide growth estimates of dubious quality. I am unaware of any past studies validating either scales or otoliths as an aging structure for bull trout.

Until such validation work can be completed, this age-growth data should be viewed as approximations. Although I am uncertain, the scale data likely results in underestimation of age and overestimates of growth. The implication of this potential error is that natural mortality estimates may actually be lower than the data would suggest. Management decisions based on such data can result in overexploitation of stocks. While a statewide catch-and-release regulation currently prohibits harvest, accurate aging will be a necessity if bull trout recovery permits future harvest fisheries.

RECOMMENDATIONS

1. Otoliths appear to provide the most appropriate aging structures for fluvial bull trout populations in Idaho. Given the depressed status of bull trout stocks in the northwest, however, scales will likely continue to be used as the primary aging tool for this species. Management must recognize scales likely provide an underestimate of age and therefore an overestimate of population mortality.

2. Where stocks are sufficiently strong, a subsample of bull trout should be aged with otoliths and scales. Surface otolith age estimates should be compared to cross section age determinations, especially for larger bull trout.

3. Aging evaluations using scales to back-calculate growth need to incorporate a minimum of 30 to 40 structures with priority given to including representative samples from all age classes. This approach shall provide a reasonable constant for use in the Fraser-Lee model. Smaller samples of otoliths can provide back-calculated estimates of growth because no body scale relation is needed.

4. Utilize PIT-tagged bull trout in Rapid River and East Fork Salmon River to further define growth relationships for fluvial bull trout.

5. Conduct age validation experiments using mark-recapture, or oxytetracycline injections in Rapid River.

6. New harvest regulations closed the harvest of bull trout effective January 1, 1994. Bull trout harvest restrictions may result in older individuals. Aging evaluations should be repeated in 3 to 6 years to assist evaluations of the regulation change.

ACKNOWLEDGEMENTS

I extend special thanks to personnel from Rapid River and Sawtooth hatcheries for their assistance in collection of aging structures and monitoring bull trout migrations at the Idaho Department of Fish and Game salmon trapping facilities. Karen Pratt, K.L. Pratt Consulting, provided review of our scale age estimates and assistance with identifying first annulus on bull trout scales. Tony Lamansky assisted with aging bull trout structures.

A P P E N D I C E S

Appendix A. Percentage of bull trout by age and length based on scale analysis from fish collected during spring 1994 in Rapid River.

		Rapid River Average Kev			
Length (mm)	Number	Age III	Aye IV	Age V	Aae VI
290	2	100			
300	1		100		
310	0				
320	0				
330	0				
340	1	100			
350	5		100		
360	8	37	37	37	
370	2		100		
380	9	33	56	11	
390	11		82	18	
400	14		64	36	
410	13	8	38	54	
420	14		57	43	
430	11		45	45	10
440	9		33	56	11
450	15		27	67	6
460	0				
470	6			83	17
480	4	25	50	25	
490	2			100	
500	3		33	33	3
510	1			100	
520	2			100	
530	0				
540	1			100	

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Appendix B. Back-calculated length-at-annulus for bull trout populations from Rapid River, Middle Fork Salmon River, East Fork Salmon River, Upper Salmon River (at Sawtooth weir), Crooked River and South Fork Boise River. Calculations based on scale samples using Frazier-Lee method with constant of -27.6.

		Calculated mean total length (mm) at annulus							
Age Group	N	1	2	3	4	5	6	7	8
Rapid River 1993-1994 data									
	29	60							
I I	88	70	143						
III	82	64	141	221					
IV	24	80	160	249	328				
V	10	69	138	217	302	402			
VI	3	58	129	204	277	366	459		
Grand mean		68	144	226	317	394	459		
Number of fish		236	207	119	37	13	3		
Middle Fork Salmon River 1993-1994 data									
	0								
II	2	52	108						
III	4	83	175	253					
IV	19	79	157	250	326				
V	24	72	139	218	305	371			
VI	10	61	123	193	269	353	422		
Grand mean		72	144	227	306	366	422		
Number of fish		59	59	57	53	34	10		
East Fork Salmon River 1993 data									
	7	86							
II	48	67	144						
III	15	59	120	183					
IV	33	88	168	262	371				
V	30	79	154	237	332	433			
VI	10	69	152	232	327	422	521		
VII	1	105	193	271	345	455	579	648	
Grand mean		75	150	237	349	431	527	648	
Number of fish		144	137	89	74	41	11	1	

Appendix B. Continued.

		Calculated mean total length (mm) at annulus							
Age Group	N	1	2	3	4	5	6	7	8
	5	87							
II	2	69	138						
III	7	69	143	222					
IV	9	76	147	224	290				
V	18	64	135	203	274	345			
VI	14	84	156	231	307	380	447		
VII	5	55	117	197	268	349	426	488	
VIII	2	56	122	186	243	298	369	446	500
Grand mean		72	141	215	285	356	435	476	500
Number of fish		62	57	55	48	39	21	7	2
<u>Crooked River and Mores Creek 1993-94 data</u>									
	24	74							
II	38	61	115						
III	27	64	119	183					
IV	7	56	116	181	274				
V	4	89	157	246	316	390			
VI	6	70	127	189	278	358	424		
Grand mean		66	119	189	286	371	424		
Number of fish		106	82	44	17	10	6		
<u>South Fork Boise River 1993-94 data</u>									
I	0								
II	0								
III	2	68	131	225					
IV	5	89	188	276	373				
V	7	80	167	238	325	402			
VI	1	73	149	221	288	369	439		
Grand mean		81	168	248	341	398	439		
Number of fish		15	15	15	13	8	1		

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